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ABSTRACT

Thirteen activities are presented that focus on a common phenomenon of a child's world: energy. These activities relate energy, how it occurs, how it is used, and how to use it safely. Each activity includes the purpose, introduction, background, procedure, materials, estimated time for the activity, typical results, safety notes, and more ideas. Student worksheets are provided for some steps in the procedure. Activities follow questions such as: How can flowing water run a machine?; How can we make work easier?; How is a battery made?; and Can recycling paper save energy? Safety is emphasized on many of these worksheets. Take-home letters are also provided so that parents can help children to develop safe energy habits. Included are a glossary, resource section, and a matrix where activities are cross referenced with the understandings, skills, and attitudes listed in the New York State elementary science syllabus. (KR)

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Energy and Safety:

Science Activities for Elementary Students

Level III
(Grades 5-6)

from the
New York Energy 
Education Project



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To Teachers

Children and science go well together. When children are being themselves, they are being scientific: observing things, asking questions, handling objects, noticing similarities and discrepancies, figuring out how something happens.

The activities that follow try to take advantage of those things that children do naturally. We've focused on a common phenomenon in the child's world: the phenomenon of energy. We've arranged a series of experiences related to energy, to how it occurs, how it is used, and how to use it safely.

We hope that you and your students will enjoy these experiences together.

The Format

The Teacher's Pages

Each activity starts with a question. The material immediately following the question is for you, the teacher.

In the Background section, key words are underlined. These words are defined in the Glossary.

The Understandings, Skills, and Attitudes are taken from the New York State Elementary Science Syllabus, soon to be available. In a few cases the wording of the Understandings has been changed to better fit the activity.

The Procedure is arranged in numbered steps. The Materials and the Safety Notes are numbered to match the steps in the Procedure.

The Student's Pages

Student worksheets are provided for some steps in the Procedure. Safety is emphasized on many of these worksheets because the use of energy involves potential hazards in many situations. Students can learn, like scientists, to satisfy their curiosity without getting hurt.

Many activities include Take-home Letters. In most cases, the use of the letters is discretionary and not necessary to the activities. We recommend using the letters because parents and guardians can help children to develop safety energy habits. Each letter includes a space for the student's name and one for the teacher's signature.

Glossary

The key words from the Background section of each activity are defined in the Glossary.

Resources

More materials for students on the same topics are listed by activity in the Resources section. You may wish to use some of this material to introduce or reinforce an activity.

Matrix

In the Matrix the activities in this booklet are cross referenced with the Understandings, Skills, and Attitudes of the New York State Elementary Science Syllabus.

Safety Note for Teachers

Students should wear protective goggles whenever any of the following are being used:

- *Hot Plates
- *Any Flame (Candle, etc.)
- *Rubber Bands
- *Any Chemicals (Vinegar, etc.)

The use of appliances or of any flame should be handled as a teacher demonstration.

Level III Activities

Grades 5-6

Question	Purpose
1. How can we use and measure the wind's energy?	To familiarize students with a form of energy available in nature, and to make them aware of the variability of wind energy.
2. How can flowing water run a machine?	To help students discover how hydropower works, and how the pull of gravity relates to the amount of energy available from a hydropower system.
3. How can we make work easier?	To make students aware of what work is, and of how machines are designed to make work easier for humans.
4. How much energy can weeds produce?	To make students aware that dried plant material is a source of energy, either directly or through the fuels produced from it.
5. Does it take more energy to heat more water?	To allow students to discover the basics of solar heating and to see that more energy is required to do more work.
6. How are our homes and apartments heated?	To encourage students to become acquainted with their home heating systems and those factors that either conserve or waste heat energy.
7. How is energy used and changed in an automobile?	To make students aware that several energy transformations occur within an automobile and that much of the energy is converted to heat.
8. How can we generate electricity?	To make students aware of the basic parts of an electric generator, and to allow them to experiment with generating a current.
9. How do electric generating plants produce electricity?	To show students that a variety of energy sources can be used to produce electricity, and to illustrate the process by which this is done.
10. How is a battery made?	To make students aware that chemical energy can be converted into electrical energy in a battery.
11. How much energy and money do appliances use?	To give students practice in using energy units, and to make them aware that using energy costs money.
12. Can recycling paper save energy?	To give students first-hand experience in recycling.
13. What is pH and why is it important?	To have students learn about acids, bases, and pH, and relate this knowledge to the problem of acid deposition.

1. Question: How can we use and measure the wind's energy?

Purpose

To familiarize students with a form of energy available in nature, and to make them aware of the variability of wind energy.

Introduction

Students construct a simple model windmill. They then carry out an assessment of the wind energy available at a given site.

Background

People have harnessed the energy of the wind for thousands of years. Wind-driven machines have pumped water for irrigation, drained flooded areas, hulled rice, ground grains and other materials, sawed wood, and pressed seeds for oils.

Then people learned to use a spinning turbine to generate electricity. Windmills became wind powered electric generators. In our country, the greatest use of windmills and wind driven electric generators occurred in the Plains States from 1850 to the 1930's. When the rural electrification program brought inexpensive electricity to these areas, however, wind machines for making electricity became obsolete. Electricity could be supplied more abundantly, cheaply, and reliably by centralized power plants.

Procedure

1. Prior to the activity, assemble all of the materials necessary for the models. Locate three places on the school property which are safe for the collection of data.

The teacher may choose to construct a windmill and anemometer before the activity so that the students have models to which they can refer. It may also be helpful to demonstrate how to complete certain steps of the procedure.

Understandings

Energy can be transferred by changing the position of objects. The greater the increase in the motion of an object the greater the amount of work that has been done on the object.

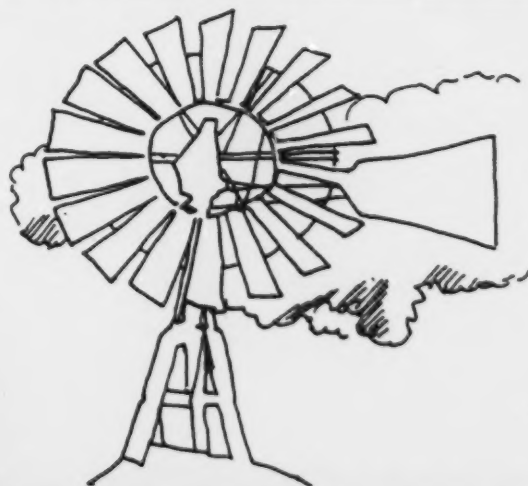
Skills

Manipulating materials
Creating models
Recording and interpreting data
Generalizing

Attitudes

Wanting explanations which lead to accurate predictions.

Enjoying working with materials and scientific techniques.



2. Conduct a pre-activity discussion.

Ask: What is the wind and how is it created in nature? How can the wind be used? How have people used the wind as a source of power in the past?

Pictures of traditional windmills would add to the discussion.

3. Carry out the activities described on the worksheets.

For the data collection, in the second activity, group the students according to how many watches are available. Appoint a time keeper for each group. If each group covers only one location, allow time for data sharing.

(If it is not possible to go outside, a fan can be used to simulate various wind conditions.)

4. After the models have been constructed and the data gathered, the teacher should conduct a post-activity discussion.

Ask: Where was the windiest spot on your schoolyard? How do you know this? Was there a difference in wind speed at the different elevations? On different days? Is the wind speed different in different places: mountain-tops, valleys, plains, etc.? How is the spinning of the windmill different from the spinning of the anemometer in this activity?

Ask: How can the wind be used to help us? If you were going to install a wind-driven electric generator (a device like a windmill which transforms the mechanical energy of the wind into electricity) on your property, where would you install it? Could you depend on it for all your energy needs?

Materials

1. paper, empty milk containers, pencils, pins and tacks, soda straws, watches

with second hands, red crayons or markers, tape, scissors, stapler, hole punch, narrow neck bottles, fan (optional), student sheets: How do windmills work? and How can you measure the wind's energy?

Estimated Time for Activity

two 45-minute class periods to make models

five 10-minute periods to measure wind speed

Typical Results

Wind will vary a great deal. Wind measuring activity will show that wind energy is not constant.

Safety Notes

3. Supervise children in the use of the punch, stapler, and pins. Control the distribution of pins and tacks to avoid mischief. Make sure that anemometers are assembled properly, so they don't fall apart in the wind.

More Ideas

Use the Beaufort Wind Scale to measure the wind speed and relate this to the spinning of the anemometer.

Determine if the winds are stronger between 2 buildings than in open areas.

Determine if there is a difference in wind speed at the same location at different times of the day, on different days, and/or at different times of the year.

How do windmills work?

The wind's energy has been used for many hundreds of years. In places where the wind was strong and steady, like near the ocean or on open plains, windmills ran machinery. How do windmills work?

The rotor was made of several blades or sails connected to a center axis. The axis was connected to a shaft. When the wind turned the rotor, the shaft had to turn also.

The rotor and shaft were mounted on a building, so that the shaft went into the building. In the building was machinery. The shaft was connected to the wheels of the machinery so it would turn them.

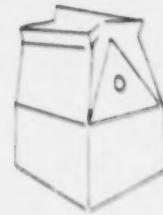
Let's make a simple model windmill.

Materials

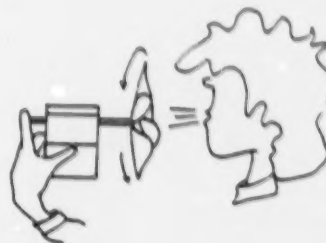
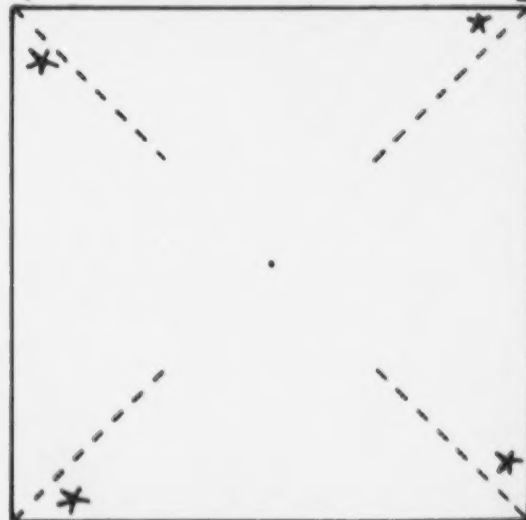
empty milk carton, pencil, pin or tack, tape, scissors, hole punch, stapler, windmill pattern, paper

Steps

1. Open the milk container, punch matching holes in each end, and staple the container closed again.
2. Cut out the windmill pattern.
3. Pin the starred corners through the center to the end of the eraser of a pencil.
4. If necessary, tape your rotor to your shaft so that they will turn together.
5. Insert the pencil through the holes in the carton and wiggle it around to make the holes large enough so that the pencil can turn freely.
6. Hold your finger against the pencil point and blow on the windmill.



Windmill pattern

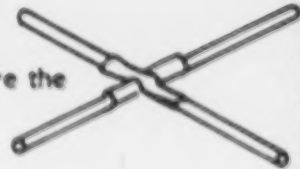


How can you measure wind energy?

Some places have a lot of wind and others don't. For example, places that are higher or more open usually have stronger winds. Before you bought or built a windmill, you would want to be sure that your location had enough wind. But how can you measure the wind?

An anemometer is used to measure wind energy. You sometimes see them at airports.

You are going to make a simple anemometer and measure the wind energy around your school.

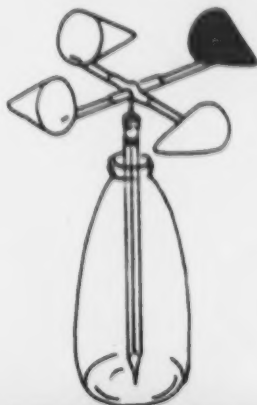
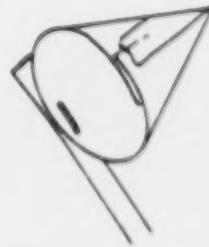
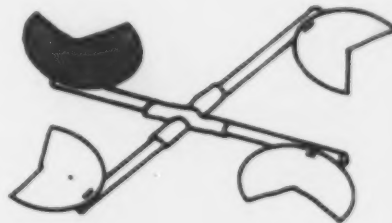


Materials for each anemometer:

pencil, pin, two soda straws, stapler, scissors, cone pattern, paper, tape, bottle with a narrow neck, stopwatch or watch with a second hand.

Steps

1. Staple 2 straws so they make an X. Reinforce with tape.
2. Cut out patterns for 4 cones. Color one cone red.
3. Staple one cone pattern to each straw end, so they all face the same way.
4. Curve each cone pattern to form a cone, and tape.
5. Pin the center of the X to the pencil eraser.
6. Insert the pencil in a narrow necked bottle, so that you can hold the bottle and the anemometer will spin freely.



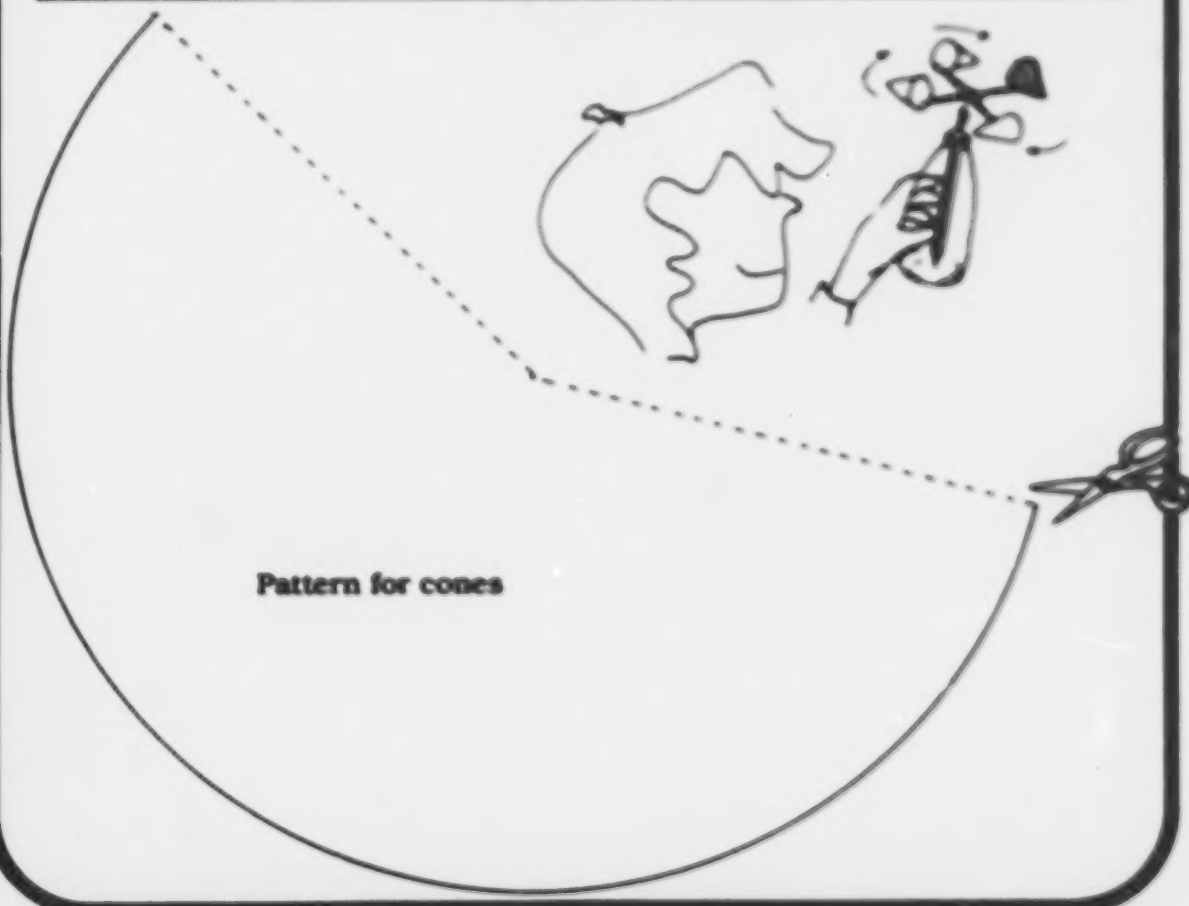
(HOW CAN YOU MEASURE WIND ENERGY? continued)

Now it's time to measure wind energy.

You will measure the wind energy at three places for 5 days. You will measure by counting the number of turns per minute. (Watching the red cone will help you count the turns.)

Use the table below to record your information.

Description of location	Number of spins per minute				
	Day 1	Day 2	Day 3	Day 4	Day 5
A.					
B.					
C.					



To _____ Folks,

This week the class is starting a unit on energy. They will be doing a number of science activities that teach about the various forms of energy, how they work, and how they can be used safely.

We'll be talking about energy from the wind, from water, and from plants. The class will be learning how energy is used to heat homes, run cars, and produce electricity. A few activities will require your help, and it will be much appreciated.

2. Question: How can flowing water run a machine?

Purpose

To help students discover how hydropower works, and how the pull of gravity relates to the amount of energy available from a hydropower system.

Introduction

Students will construct a simple water wheel and investigate some variables that affect how fast it will turn.

Background

People's use of running water as a source of energy can be traced back to ancient civilizations. Early people used running water for transportation and powering machinery to grind grains and sharpen tools.

Today, water is collected behind dams in large lakes called reservoirs. This water is then released through penstocks (chutes) to spin turbines (giant waterwheels) which in turn spin generators within a power plant. In this process the pull of gravity gives mechanical energy to the running water. That mechanical energy is finally transformed into electrical energy in the generators.

The energy that can be obtained from a body or stream of water depends on two factors:

1. the head or height from which the water falls, and
2. the flow or amount of water that passes in a given period of time.

The higher the head and the greater the flow, the more energy is available.

The disadvantage of water power is that the water does not always flow at the same rate: spring floods and summer droughts often make power unavailable while cold spells can block rivers with ice jams. These variables can be controlled through the use of dams. However, damming water to make a reservoir means flooding an area of land.

Understandings

Energy can be transferred by changing the position of objects. The higher an object is lifted the more work must be done on the object and the greater the amount of energy transferred to it.

Skills

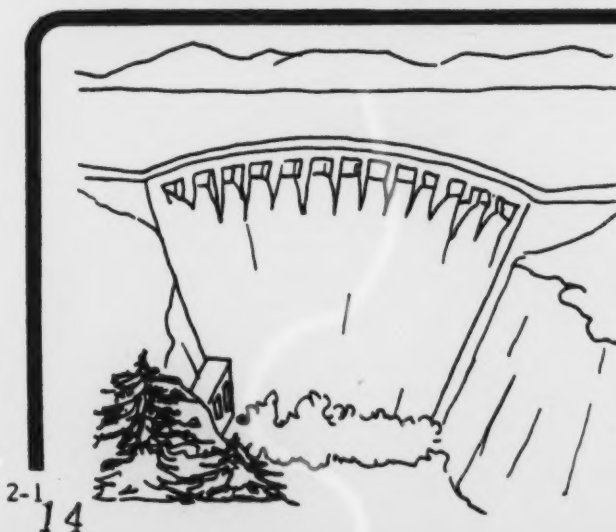
Manipulating materials
Creating models
Observing
Generalizing

Attitudes

Enjoying working with materials.

Wanting explanations which lead to accurate predictions.

Although water power supplies only about 5% of the total energy we consume, its use in some regions of the country has decreased our dependence on non-renewable fuel supplies such as fossil fuels. The disadvantages of water power must be weighed against its advantages; it is an economical and renewable source of energy.



Procedure

1. Before doing the activity:
 - a. Obtain the soup cans and use a hammer and nail to punch holes in the bottom of the cans. Make sure that all sharp edges on the cans are smoothed.
 - b. Gather cardboard, dowels, and other materials.

2. Introduce the activity with pictures of waterwheels and hydroelectric dams.

Ask: What did people use water power for in the past? What do we use it for today? (Example: Niagara Power Project.) How does water power work? What makes water run downhill? How does the water get to the high places that it runs down from? Does a high waterfall have more energy than a low one?

Review the water cycle and gravity.

Explain that the sun's energy evaporates water which rises and forms clouds. Wind moves clouds from one place to another, and rain falls, often at high elevations. Because of gravity the water runs from higher places to lower places.

3. Organize the students into groups of 3 to complete the activity procedure. If the classroom does not have running water, the teacher should fill a large container, such as a plastic garbage can, from which the students may draw water. Discuss how to set up the equipment for releasing and catching the water.
(This activity is messy! If you can do it outdoors, do so.)
4. Discuss the data and questions - emphasizing the transformations of energy, how running water has been used to replace the muscle power of humans and animals, and the similarities between a waterwheel and a turbine in a hydroelectric plant.

Materials

1. cardboard; 3/8" wooden dowel, cut in 15" lengths; pencils; scissors; stapler; tape; small (4 oz.) paper cups; large soup cans; plastic pail; How do you construct a waterwheel? sheet

Estimated Time for Activity

two 45-minute class periods

Typical Results

Wheels should turn faster when water falls from a greater height.

Safety Notes

1. The teacher should supervise the hole punching, cutting, and stapling.

Make sure that all containers used for the activity have been properly cleaned and prepared to avoid possible cuts and infections.
2. This activity is messy; if at all possible, do it outdoors. If you must work indoors, have sponges or mops ready to clean up any water that may spill on the floor and produce a slippery condition. Remind students to keep their fingers over the hole in the soup can so that water does not escape until it is needed for the activity.

More Ideas

Vary the amount of water in the can and the size of the hole to see if this affects the speed of the waterwheel.

Construct paddle wheels and other designs for using water power. Test them in a sink or in a nearby stream, if possible.

How do you construct a waterwheel?

Materials

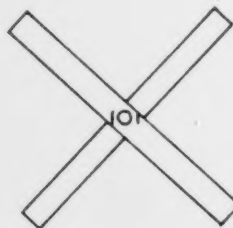
two desks; a plastic pail; 4 (4 oz.) dixie cups; metric ruler; tape; stapler; red felt-tip pen; scissors; cardboard; piece of wooden dowel; and a large soup can with a hole in the bottom.

Steps

1. Color the outside of one of the cups with a red felt pen.
2. Cut two rectangular cardboard strips from the milk carton 30 cm by 6 cm. (See diagram A.)

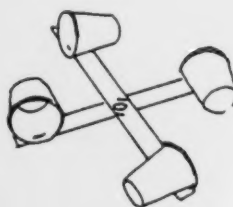
3. Crisscross the two strips of cardboard. Then staple them together where they contact. Find the center and punch a hole just large enough to force the dowel through.

A.



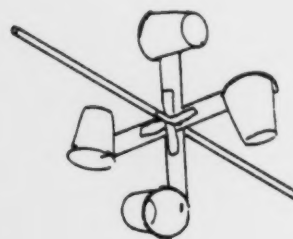
4. Glue and staple the four dixie cups to the ends of each strip all facing in the same direction. (See diagram B.)

B.



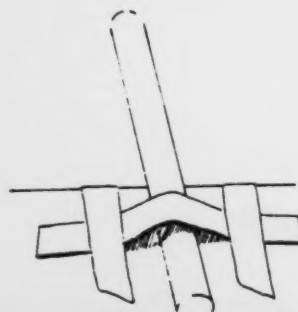
5. Insert the dowel through the cardboard strips. Glue or tape the dowel to the cardboard (see diagram C), so that it turns freely with the cardboard strips when the cups make them spin.

C.

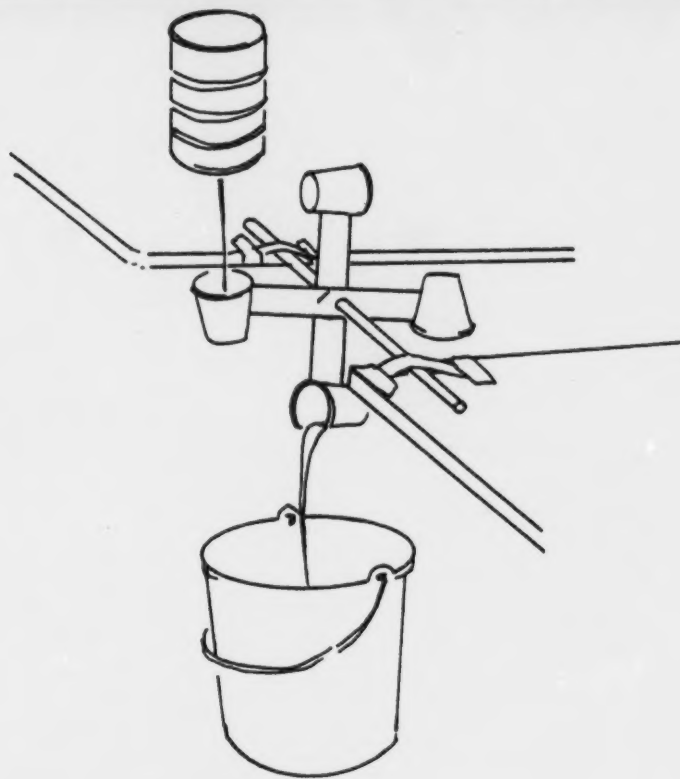


6. Set up two desks and a pail - outdoors is best, in case water splashes. Push the two desks together so that each end of the dowel can rest on a desk. Tape cardboard over the ends to hold them in place loosely. (See diagram D.) Test to make sure that the waterwheel will turn freely when water falls on it.

D.



7. Obtain a large soup can from your teacher. Fill the can with water, holding your finger over the hole so no water escapes.
8. Hold the can of water 20 cm above the cups and take your finger off of the hole so that water falls directly into the cups. Continue to let the water fall for a minute and count the number of spins that your waterwheel makes in this time.
9. Repeat step 8 but this time position the water can 40 cm above the cups.



Answer these questions:

1. What makes the wheel turn? _____
2. How many times per minute did your wheel turn when it was 20 cm above the cup? _____
3. How many times did it turn when it was 40 cm above the cup? _____
4. Does the height of the water affect the speed of the wheel? _____
5. What do you think would happen if you made the hole in the can bigger? _____
6. What do you think would make a real waterwheel on a river turn faster or slower? _____
7. What is water power used for today? _____
8. How could using water power help to save other kinds of energy? _____

3. Question: How can we make work easier?

Purpose

To make students aware of what work is, and of how machines are designed to make work easier for humans.

Introduction

Students will study the scientific meaning of the word work, by trying two simple techniques that affect forces necessary to move various objects.

Background

Energy is defined as the ability to do work. Work, in a scientific sense, is done when a force is exerted on some mass to move it over a distance. By measuring the amount of force and the distance it moves, and multiplying the two numbers, the amount of work can be calculated.

For example, if a 50 gram object is lifted 10 centimeters the amount of work would be calculated as follows:

$$\text{work} = \text{force} \times \text{distance}$$

$$\text{work} = 50 \text{ g} \times 10 \text{ cm}$$

$$\text{work} = 500 \text{ g cm}$$

The amount of work is then 500 gram centimeters. The "driving force" that causes the work to be done is energy.

There are a number of ways that humans have discovered to make work easier for themselves. For instance, a series of pulleys will make lifting a heavy object easier. The person pulling on a rope moves the rope a greater distance while exerting a smaller force than would be necessary to simply lift the object without the pulleys.

All machines operate on this basic principle, even though it is not always as obvious. Simple machines make it easier to do work by causing force to be more conveniently exerted.

Understandings

Energy can be transferred by changing the position of objects.

The amount of work done on an object depends on the size of the force and the distance the force is applied to the object.

Many devices made by humans are made of levers or inclined planes in combination, which can be used to transfer energy.

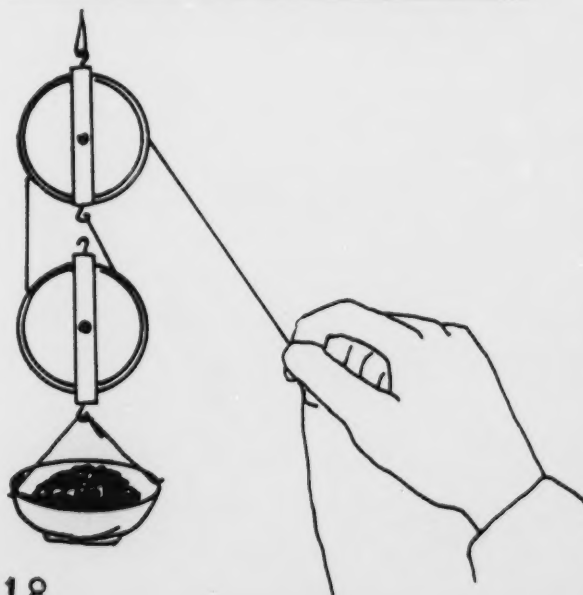
Skills

Manipulating materials
Observing
Measuring
Recording data
Formulating hypotheses

Attitudes

Valuing the practical and technological.

Valuing skepticism, careful investigation, and logical reasoning.



In this activity, lubricant is used to reduce friction, just as we use oil in an engine. When we must work against friction, we must use more force. An inclined plane is used to reduce the force needed to raise an object. The object travels a greater distance, but requires less force.

Procedure

1. Introduce the concepts of energy, and force. A good example would be of a person and a fork lift moving a box from a warehouse to the back of a truck.

Ask: Does the worker have energy? Where does the energy come from? Does the fork lift have energy? Where does it come from?

Ask: Suppose the box weighs 20 kilograms. Can either the worker or the fork lift exert enough force to lift it?

Ask: Suppose the box weighs 200 kilograms. What kinds of things could the worker do to help get the box from the warehouse to the truck and up into the back of the truck?

Ask: What is work? If the worker gets the box into the truck, has work been done? If the worker pushed the box but it doesn't move, has work been done? What is friction? Why does friction make work harder? How can we overcome friction?

2. Discuss the idea that a word definition of something can often be translated to a mathematical definition. This allows scientists to measure and calculate exact values of the quantity being defined.

Work is a good example of this.

Work = force x distance

3. Divide the students into groups of 3 and give each group a set of materials and their student sheets.
4. Go over the student sheet with the class, pointing out in particular how to use and read the spring balance.

5. Have each group do the activity. Have each student measure the force in each situation and record the results obtained on his or her own sheet.
6. At the completion of the activity discuss the concepts of energy, force, distance and work as they relate to this activity. Use the worksheet questions as a basis for this discussion.

Materials

3. Can you make work easier? sheets

for each team: spring balance; string; meter stick; toy cart on wheels (from home or from elementary science kits); vegetable oil; a four foot board, about 6" wide

Estimated Time for Activity

one 45-minute period

Typical Results

More force will be required to pull the cart on its top than on its wheels. When oil is used, the force to pull the cart on its top should decrease.

To lift the cart will require more force than to pull it up the ramp.

Safety Notes

3. Don't give children vegetable oil. Give them a rag soaked in oil to wipe the desk top with, and follow through with clean-up immediately.

More Ideas

Use string and desk or chair rungs to set up pulley arrangements, to see how pulleys reduce the force necessary to lift an object.

Bring an auto jack into the classroom. See if students can figure out how the jack is used to lift a heavy car.

Can you make work easier?



Work means using a Force
to move something over a Distance.

$$\text{Work} = \text{Force} \times \text{Distance}$$

Over the centuries, humans have figured out many clever ways to move things without having to work so hard. In other words, they used less force to move the same things. Can you think of some ways to do this? You will be trying some of them today.



Materials spring balance, string, cart, oil, board, meter stick

Steps Each of you should do each step.

- A.
 1. Attach a string to your cart, and attach the spring balance to the string.
 2. Measure 20 centimeters on your desk top. Mark the start and finish with tape or pencil.
 3. Roll the cart from the start to the finish by pulling the spring balance. Read the force number from the spring balance as the cart is moving.
 4. Record the force and distance on your sheet. What was the amount of work done?
 5. Now turn the cart over so the wheels are in the air. Slide the cart 20 cm while reading the force.
 6. Record the distance and force on your sheet. What was the amount of work done?
 7. Oil the top of the desk. Now slide the cart again, and record the numbers.
 8. What was the amount of work done?



- Did the oil make any difference?
9. What was the easiest way to move the cart (least work)?
10. What was the hardest way (most work)?

- B.
 1. Place the cart on the floor. Measure the distance from the floor to the seat of a chair.
 2. Lift the cart from the floor to the seat of a chair by suspending it from the spring balance.
 3. Read the force number while you are lifting the cart.



4. Record the force and distance on your sheet. What amount of work was done?
5. Set up the board so that it makes a ramp from the floor to the seat of the chair. Have one person hold each end in place.



6. Slide the cart up the ramp upside down. Read the force, and record it.



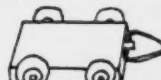
7. Now roll the cart up the ramp. Read the force and record it.

8. Each time, you raised the cart to the same height. Was the force the same each time?

Was the distance the same?

Was the work the same each time?

9. Which method was the most work?
10. Which method took the least work? Why do you think it took the least work?

A.		Force	×	Distance	=	Work
Cart on Wheels		_____		_____		_____
Without Wheels		_____		_____		_____
Without Wheels, on Oil		_____		_____		_____
B.		Force	×	Distance	=	Work
Lifting Cart		_____		_____		_____
Sliding Cart Up Ramp		_____		_____		_____
Rolling Cart Up Ramp		_____		_____		_____

4. Question: How much energy can weeds produce?

Purpose

To make students aware that dried plant material is a source of energy, either directly or through the fuels produced from it.

Introduction

Students will collect, dry, and weigh a sample of weeds. They will then calculate the dry weight and energy from an acre of such weeds. Finally, students will determine how many acres of their weeds would be necessary to produce the energy consumed by the United States each year.

Background

Plants, from algae to trees, contain chemical energy which was created through the process of photosynthesis. This plant material, known as biomass, can be dried and burned directly, transforming the chemical energy into heat energy. In addition, it may be treated through biochemical and thermochemical processes to produce methane, alcohol, ammonia, oil, gas, and charcoal, all of which may also be utilized as fuels.

Growth and harvesting of biomass as a fuel is an alternative currently being investigated to reduce our reliance on other fuel resources. Kudzu, kelp, water hyacinths, land perennials such as eucalyptus and sycamores, and farm and forest residues and wastes are being used as fuel sources.

Procedure

1. Before taking students outside, identify an area where you and your students can gather weeds. Check the area for poisonous plants.
2. Before the activity, discuss with the class how our energy problems today are related to increasing demands for energy, while the resources we depend on most are finite. Develop the idea

Understandings

The leaves of green plants absorb light energy from the environment and transform it into forms which can be used and stored.

Skills

Manipulating materials
Measuring
Recording and interpreting data
Developing vocabulary
Acquiring and communicating information

Attitudes

Appreciating the natural world as an essential resource in fulfilling human needs.

Valuing investigative procedures which are well designed and safe.



that utilizing new fuel resources and alternative forms of energy, as well as conservation techniques, help to alleviate our energy problems. Discuss what biomass is and how it can be used as an energy resource.

3. Discuss the collecting process, safety precautions, and the measuring techniques to be used upon returning to the classroom. Caution students about bottles, broken glass, cans, bottle caps. Take an extra garbage bag for these items. If possible, have one student on each team wear gloves and be responsible for handling trash.
4. Organize the children into teams of 4-5 for the activity. The number should be determined on the basis of equipment and the availability of suitable sites for collection of weeds. (You may wish to send a small group of students to gather weeds for the entire class instead.) Assign students responsibilities for carrying equipment and working before going outside.
5. The activity should be done in three stages: 1) collection and initial weighing should take place on one day; 2) drying should occur for five days; and 3) final weighing and class discussion should occur on the final day of the activity.
6. After the activity procedure is completed discuss the summary questions. Also have students calculate the weight and energy content of one acre of the weeds. Note: an acre contains 4085 square meters, and a dry kilogram of biomass yields roughly 850 kilocalories. Do a sample calculation on the board to help with this.

Materials

3. extra garbage bag for trash
5. for each team:
2-3 scissors or clippers; a garbage bag; a meter stick; 4 meters of string; stakes or stones; gloves, if possible; metric scales
6. Weeds for Energy? sheet

Estimated Time for Activity

1.5 hours for collecting, weighing, and calculating

5 days for plant drying

Typical Results

Students should find that the weight

loss will vary according to the types of plants collected. Thus their values for the dry weight and biomass energy from an acre of weeds may differ between teams.

As an illustration, a square meter sample of weeds that has a dry weight of 2 kilograms would provide a dry weight of 8170 kilograms per acre ($4085 \text{ sq.m./acre} \times 2 \text{ kg./sq.m.}$) and 6,944,500 kilocalories of energy per acre ($850 \text{ kcal/kg.} \times 8170 \text{ kg./acre}$). So 2,736,000,000 acres of such weeds would be needed to produce the 19 quadrillion kilocalories of energy required by the United States each year.

Safety Notes

1. Before entering the field, the teacher should be aware of students who have allergic reactions to weeds and/or bee stings. Also watch out for poison ivy.
3. Handle cans and bottles with a rake or shovel, or wear work gloves. Caution students to leave trash for those who are assigned to handle it.
5. Provide plastic gloves for those students handling weeds who may have allergies. Students should wash hands thoroughly after collecting and weighing the weeds.

Drying the weeds should be done by the teacher if an oven is used; otherwise, place the weeds in sunlight in windows with a southern exposure. If there are several teams of students, a large area will be needed for drying. In addition, a method for identifying each team's bag should be developed.

When weighing, the students may have to divide the biomass into piles, weigh each pile separately, and then find the sum of all the weights to obtain the weight of a square meter of biomass. The worksheet is based on metric units, so weight units must be metric or be converted into metric.

More Ideas

Make a bar graph comparing team results.

Do research on biomass energy crops like those mentioned in the background section.

Weeds for Energy?

Why not?

You know that your body gets energy from food that comes from plants.

You also know that wood from trees can be burned for energy.

Why not weeds? Weeds, like any other plant, store energy from the sun. They can be burned as fuel, or they can be broken down to make gas or liquid fuels.

Let's collect some weed fuel, and figure out how much energy it could give us.

Materials

garbage bags, scissors, grass clippers, meter stick, string, stakes or rocks, a weedy vacant lot, and metric scales.

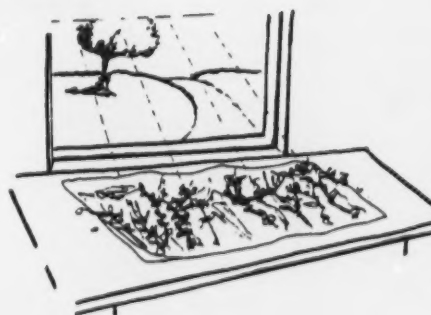
Steps

1. With your team, measure and area a meter square where you can collect weeds. Mark the sides with string and the corners with stakes or stones.
2. Using your scissors and clippers, trim the area down to about 2 centimeters from the ground. Cut everything you clip into short pieces and put it in your team's garbage bag.
3. Put anything that won't burn -- glass, tin cans, etc. -- into the class trash bag.
4. Back in the classroom, weigh your garbage bag. Record the fresh weight on the table on the next page.
5. Open the garbage bag and fold back the top so that the weeds are exposed to the air. Put the bag in a sunny place for a week. Turn over the weeds and shake them each day. Then close it and weigh it again. Record the dry weight on the table.
6. Find the weight loss and record it on the table.

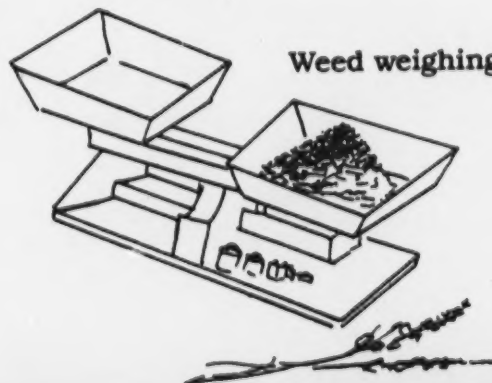
Weed gathering



Weed drying



Weed weighing



Weed Weights

Fresh weight (in kilograms)	—	Dry Weight (in kilograms)	=	Weight loss (in kilograms)

Answer these questions

1. What happened when you dried the weeds? _____
2. What do you think made this happen? _____
3. Were the weeds a better fuel before or after drying? Why?

Plants can be grown, harvested, and burned for their energy. When we get energy from plants in this way, we call it biomass energy. Biomass means material that was once living.

Let's see how much energy we could get from an acre of weeds like yours.

Number of square meters in an acre	X	Dry weight of a square meter of weeds	=	Dry weight of an acre of weeds
4085	X	_____ kilograms	=	_____ kilograms

Biomass energy per kilogram of dried weeds	X	Dry weight of an acre of weeds	=	Biomass energy from an acre of weeds
850 kilocalories (or 7500 Btu per pound)	X	_____ kilograms	=	_____ kilocalories

Answer these questions

1. Oil and coal are called non-renewable fuels, because when we use them up, they are gone for good. Biomass is called a renewable fuel. Why?

2. Would it be better to also dig up the roots when you collect biomass? Why or why not?

3. The United States uses 19,000,000,000,000,000 kilocalories of energy a year. How many acres would it take to grow that energy as biomass?

4. What problems would growing that much biomass present?

5. Question: Does it take more energy to heat more water?

Purpose

To allow students to discover the basics of solar heating and to see that more energy is required to do more work.

Introduction

Students will calibrate their own graduated cylinders. They will then experiment with different volumes of water to collect solar energy. They will graph their results to discover that a larger volume of water will show less rise in temperature.

Background

Heat and temperature are different. You can use a lot of energy trying to heat a very large amount of water, yet the temperature of the water won't change much. The same amount of heat energy, applied to a small amount of water, will make the water boil.

Next to space heating, the water heater is the biggest energy user in the home. The average household uses energy resources such as fuel oil, electricity, natural gas, coal, or wood for heating water for domestic use in cleaning, bathing, and space heating. Solar collector systems are also used to heat water.

When hot water is wasted, therefore, energy is wasted. This includes dripping faucets, unnecessarily high water temperature settings, and uninsulated water tanks and pipes. The best water heating system is one that heats just enough water at the right times, and doesn't let that heat escape.

Solar designers have learned that if they try to heat too much water with sunlight, they can only achieve lukewarm temperatures. The system must be sized correctly to produce hot water. Since sunlight is diffuse and limited the energy that can be obtained from it is also limited. A solar hot water system must be planned to produce just enough to meet the user's needs.

Understandings

Heat flows spontaneously from warmer objects to colder ones. Larger amounts of the same material absorb or lose larger amounts of heat energy for a particular temperature change.

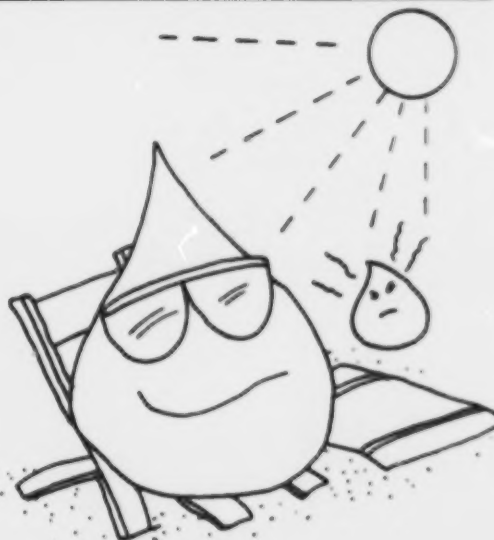
Skills

Observing
Measuring
Recording and interpreting data
Formulating hypotheses

Attitudes

Valuing careful investigation and logical reasoning.

Valuing truthful reporting of findings.



It would be good if all consumers, whatever kind of energy they use, would look twice at their hot water consumption. This activity is designed to make students aware that it takes more energy to heat a larger volume of water.

Procedure

1. Start by having the class make graduated cylinders out of clear plastic cups and indelible markers. Use one good graduated cylinder to measure volumes into their cups. The students calibrate their cups by setting the cups on a level surface and marking each volume on the side of the cups with markers. For this activity, only 50 and 100 milliliter marks are needed.
2. Divide class into teams of two. Have each team set up and carry out the comparison of two volumes of water, and record and graph their data. If bright sunlight is not available, use sunlamps.
3. Use the computer program Hot Water Plot to graph the data students collect.
4. Compare and discuss the teams' results, and their answers to the questions. Point out that the more hot water you use, the more energy you use. Ask how they think hot water can be conserved.

Materials

1. a graduated cylinder, clear plastic cups, indelible marker, water
2. south-facing windowsill, clock or watch
for each team:
2 plastic cups, 2 thermometers, 1 sheet of aluminum foil 25 cm square, water, sunlamps if necessary, Getting into Hot Water sheet
3. Hot Water Plot computer program, Commodore 64 micro computer

Estimated Time for Activity

0.5 hours to set up the activity

1 hour to collect data

0.5 hours to construct graph and answer questions

Typical Results

The cup with the larger volume should increase in temperature at a slower rate than the cup with the smaller volume, assuming the amount of heat received was equal. It will also lose heat at a slower rate.

Safety Notes

2. Students should be cautioned about the fragility of thermometers.

Keep sponges or paper towels handy for spills.

More Ideas

Try insulating the cups to slow down heat loss. See whether this also affects heat gain.

Carry out a controlled experiment with a hot plate, a clock, and different volumes of water. See what temperature different volumes will reach in a given time, or how long it takes different volumes to reach a given temperature.

Construct solar collectors with shoeboxes, foil, tin cans, and saran wrap. See which can achieve the highest temperatures.

Design a math problem on how much energy is needed to heat water for a shower.

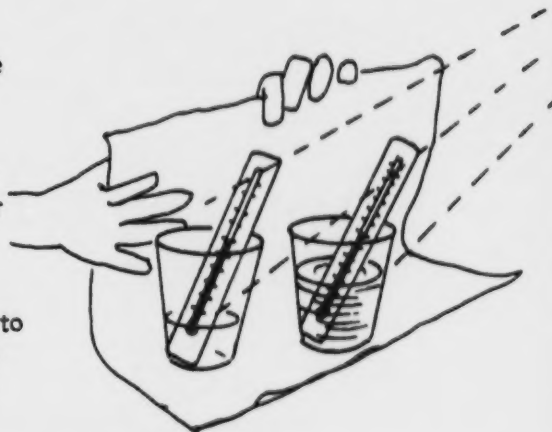
Getting into Hot Water

Materials

2 clear plastic cups, 2 thermometers, aluminum foil, cold water, tape

Steps

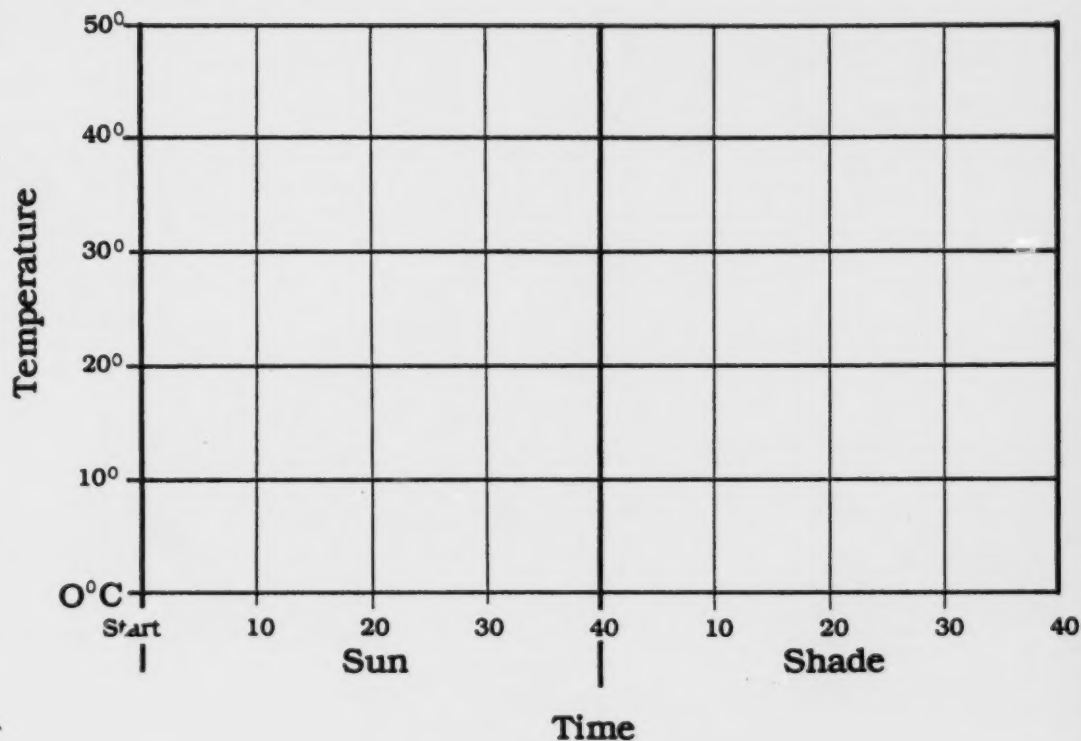
1. Put 50 milliliters of cold water in one cup and 100 milliliters in the other. Place a thermometer in each cup.
2. Take the starting temperature of the water in both cups and record on your sheet.
3. Place the aluminum foil on a sunny windowsill. Put the cups on it, close to the outside edge. Fold the foil up, so that it makes a wall behind the cups, facing out.
4. After ten minutes, take the temperature of the two cups of water again. (Stir the water gently with the thermometer before you read the temperature). Record the temperature on your sheet.
5. Repeat step 4 after 20, 30, and 40 minutes.
6. Now remove the cups from the windowsill and put them in a shady place.
7. Record their temperature in the shade after 10, 20, 30, and 40 minutes.



		Temperature in the sun					Temperature in the shade			
	At the start	After 10 min	After 20 min.	After 30 min.	After 40 min.		After 10 min.	After 20 min.	After 30 min.	After 40 min.
100 ml cup										
50 ml cup										

Graphing Heat Gain and Loss

Now make a line graph showing the temperature change for each cup. Use 2 different colors, if possible. Mark each line 100 ml cup or 50 ml cup. Describe your observations about the two cups of water.



Did they react differently? _____

Was the sunlight the same on both cups? _____

Which cup reached a higher temperature? _____

Does that mean that it absorbed more energy? _____

What does it mean? _____

Wasting hot water
is like pouring energy
down the drain.



Energy for the future:
save it!

6. Question: How are our homes and apartments heated?

Purpose

To encourage students to become acquainted with their home heating systems and those factors that either conserve or waste heat energy.

Introduction

Students will study the heating systems used in their homes or apartments. They will create floor plans of their residences and survey the air temperatures at different levels in each room. They will finally discuss ways to make their homes or apartments more heat efficient and comfortable.

Background

Due to higher fuel costs, aging heating systems, or a combination of both, families spend increasing amounts of their income to heat their homes or apartments. Rising energy costs have been a major factor contributing to rising rents.

Furnaces utilizing natural gas or fuel oil are designed to heat air or water, which is then circulated to heating units located in the rooms of the dwelling. On the other hand, the air in rooms in an electrically heated home/apartment is heated by individual units within each of the living areas.

Whichever system is employed, the temperatures generated are usually controlled by one or more thermostats located in the dwelling. Thermostats sense the air temperature in a variety of ways: some contain a bi-metallic strip which expands/contracts in response to the air temperature to complete an electrical circuit; others contain an ampule of mercury which completes an electrical circuit as it is tilted by a metallic coil which expands/contracts in the thermostats according to the room air temperature. When the circuit is completed, the furnace or electrical heating units in a room are activated to heat the air until the room temperature rises to the thermostat setting.

Understandings

Animals obtain energy in various forms from the environment.

Energy must be added to a complex system to maintain the interactions.

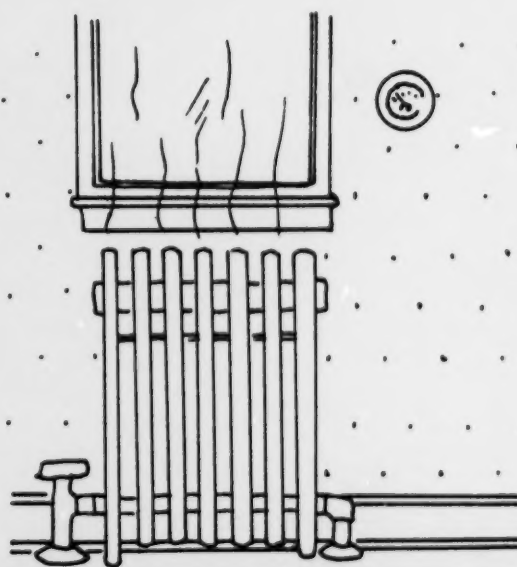
Skills

- Observing
- Measuring
- Recording data
- Creating models
- Questioning
- Acquiring and communicating information

Attitudes

Valuing careful investigation.

Wanting useful information for solving problems.



Many factors can contribute to the efficient functioning of a heating system:

- regular maintenance of the furnace;
- insulating hot water pipes and hot air ducts;
- not blocking radiators and baseboard heaters with furniture or drapes;
- use of insulation, caulking and weatherstripping;
- avoiding large glass areas on the north and west sides;
- lowering shades and drawing drapes on cold nights;
- locating the thermostat away from drafts or direct sunlight and fairly high on the wall;
- keeping the thermostat at 65°F in the daytime and 55°F at night (unless there are older people in the home).

Procedure

1. Prior to doing the activity, the teacher should:
 - a. duplicate sufficient quantities of materials for the class;
 - b. obtain necessary equipment to complete the activity procedure;
 - c. discuss in general terms how homes and apartments are heated, the fuels needed, and how thermostats work; and
 - d. decide if step 5 is to be modified or completed by the students. If thermometers and magnetic compasses are to be used, conduct a brief review of their use.
2. Pass out the activity worksheets and equipment. Discuss the data to be gathered and how to conduct an interview with an adult who may assist the student in completing the data section. Demonstrate how to make the key and sketch of the dwelling which includes the information desired. Preparation of an overhead transparency prior to class will help the discussion.
3. If step 5 is modified due to equipment supplies, inform the students at this time of the modifications. These might include eliminating the step completely, measuring the temperatures only where the thermostats are located, or having selected students measure the temperatures and present their findings to the class.
4. The activity should be completed by the students as a home assignment.
5. Student worksheets should be discussed on the following day. If time is available, give each student a blank transparency and marker; direct each to make a copy of the sketch which will be projected to the class. Compare the different arrangements discovered by the class. Use a transparency of the Room Temperature Profile to display some student data.
6. Discuss these questions in class.
 - a. How would placing a thermostat in each of the following places affect the heating of your home/apartment?
 1. near a window or door
 2. on a wall which receives direct sunlight
 3. near a lamp
 4. in the coolest room of the house/apartment
 5. in a draft

6. on a wall above one of the heating units
- b. Where would you recommend placing the thermostat in your apartment or house? Why?
- c. How could the thermostat be adjusted to save energy?
- d. Why do some homes/apartments have more than one thermostat? Of what value is this?
- e. What kinds of things can people do to keep a steady, comfortable temperature in their homes during cold weather?

Materials

2. 3 student sheets: How is your home/apartment heated?, Home Heating Worksheet, and Room Temperature Profile.

for each student: metric ruler, thermometer, compass (optional)

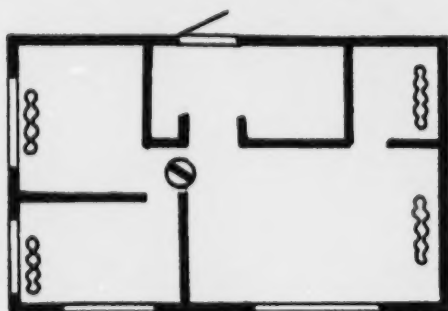
Estimated Time for Activity

2-3 hours, including both homework and classwork

Typical Results

The students floor plans and temperature profiles will vary considerably, depending upon such factors as location of heating units and the setting and height of the thermostats.

Sample floor plans are provided below:



Sample Floor Plans

Safety Notes

1. Contact the home before doing the activity to inform parents about its purpose and their involvement in the process.
2. Investigating the furnace area is not necessary for this activity. Advise students to investigate the furnace area only in the presence of an adult and not to tamper with any thermostats. If the student lives in an apartment, contact should be made with the building supervisor before investigating areas outside of the apartment.

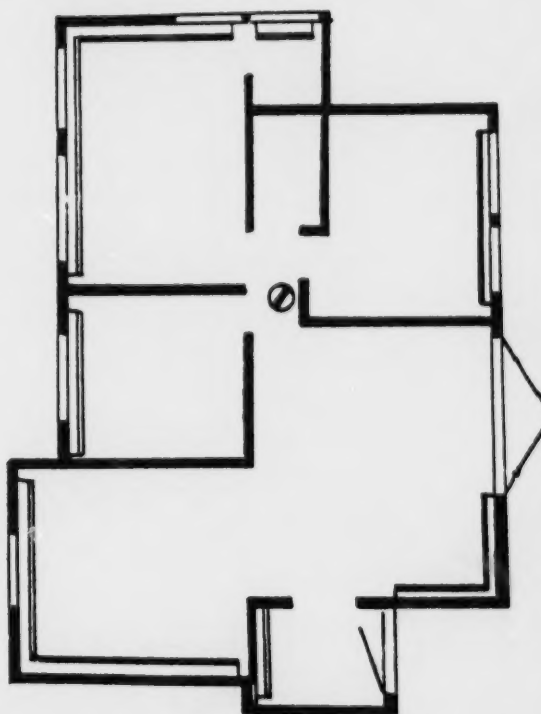
Remind students that thermometers are fragile.

More Ideas

Make a model or diagram which illustrates how a thermostat works internally.

Discuss how an automatic or clock thermostat works and the benefits associated with its use.

Ask a heating expert or the head custodian to talk to the class about heating system problems.



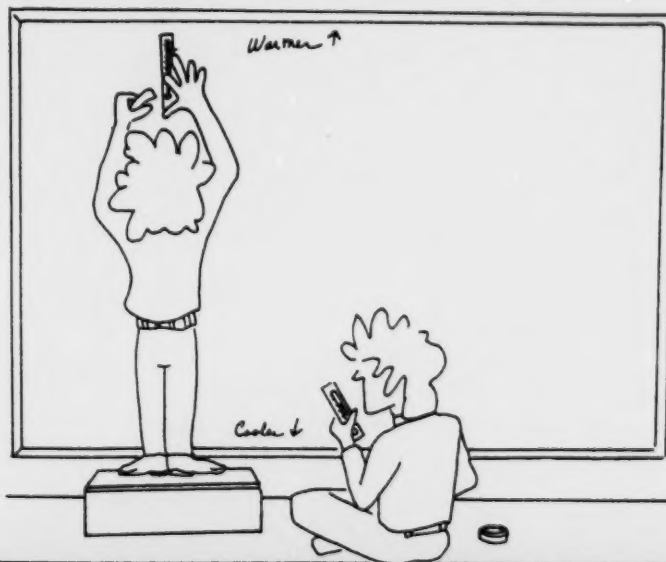
How is your house/apartment heated?

Materials

a copy of the Home Heating Worksheet, a copy of the Room Temperature Profile, a pencil, a metric ruler, a celsius thermometer, and a compass (optional)

Steps

1. Fill in the data asked for on the top of the Home Heating worksheet. Ask an adult to help you if you do not know all the answers.
2. Before you make a sketch of your apartment or home, make up a key. Choose different symbols to stand for windows, doors, heating units, and thermostats. Include these on the worksheet.
3. Make a plan showing each floor of your apartment or house. Include the information mentioned in step 2. Draw an arrow on one corner of the plan to show where North is.
4. After you have completed the plan, measure to the nearest centimeter how far above the floor the thermostat is placed. Indicate this height on your diagram. If your apartment does not have a thermostat, find the place outside your apartment where the thermostat that controls your heat is located. Note this location on your diagram; also include a description of the location, including the distance of the thermostat from the floor.
5. Now, measure and record on the Room Temperature Profile the air temperature near the floor, at the level of the thermostat, and near the ceiling in each room of your house or apartment. Make sure that you record the time of the day when you take your measurements.
6. Be prepared to present your information to the class.



Home Heating Worksheet

Basic Data:

Type of heat: (circle one or more) gas oil electric coal wood solar

of rooms heated = _____

of floors in dwelling
(include heated basements and attics) = _____

Type of heating units
(radiator, baseboard, etc.) = _____

Location of furnace = _____

Furnace located in: heated area or unheated area (circle one)

Furnace heats: air water (circle one)

of thermostats = _____

Height of thermostats = _____

Floor plan

Key

Doors	
Windows	
Thermostat	
Heating units	
radiators	
baseboard units	

Room Temperature Profile

Time of day _____

[illegible]

To _____ Folks,

This week the class is learning about HOW OUR HOMES AND APARTMENTS ARE HEATED. Your help and cooperation are important. They will be collecting basic data about how your home is heated, and will be drawing a floor plan to show the location of windows, doors, thermostats, and heating units.

This may require some help from you, and I greatly appreciate your assistance in this project.

7. Question: How is energy used and changed in an automobile?

Purpose

To make students aware that several energy transformations occur within an automobile and that much of the energy is converted to heat.

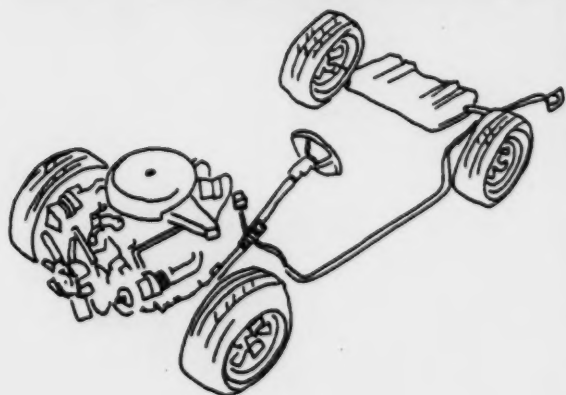
Introduction

This activity will guide students through the energy transformations that take place in a car. Questions asked will help students understand that all fuel used in a car does not end up as useful energy for operating the car.

Background

Modern machines use energy to provide power to do work. Energy changes are governed by the Laws of Thermodynamics which state that energy can be transformed from one form into another and that in this conversion some of the energy is changed into heat. Machines control or regulate these changes. The automobile, a machine that influences all of our lives, is a good example of energy conversions.

The internal combustion engine in automobiles is one of the foremost consumers of petroleum, but it is energy inefficient, usually operating at a 15% efficiency to move the vehicle and its load. Understanding the energy changes that must take place in an



Understandings

Material and energy may be changed in form more than once as interactions occur within a complex system.

The total material and energy within a system may decrease as some is lost to the surroundings.

Skills

Observing
Replicating
Recording and interpreting data
Classifying
Developing vocabulary
Using cues

Attitudes

Welcoming the unknown or the ambiguous.

Valuing the practical and technological.

automobile and the areas where energy may be lost can help the individual develop a strategy for conserving gasoline and saving money, while prolonging the life of the automobile.

Initially, gasoline containing chemical energy is pumped to the carburetor where it is mixed with air. Next it is fed into chambers known as cylinders, where it is compressed and ignited by a spark. Here, the chemical energy in the gasoline is converted into heat, light, and sound, and the burning produces gases. These heated gases inside the chamber expand, causing the piston to move. Thus, heat is converted to mechanical energy.

In most cars the up and down motion of the pistons (4, 6, or 8 of them, one for each

cylinder) is changed to rotary motion by the crankshaft. The mechanical energy is next transferred through shafts and gears to the transmission, then to the drive shaft, then to the universal joint and finally to the wheels which propel the vehicle forward.

The mechanical energy of the crankshaft also turns the alternator which makes an electric current. That electrical energy is used to run the car's electrical system including the lights, the starter motor, the spark plugs, and the radio. The excess electricity is converted to chemical energy in the battery.

Finally, exhaust gases and large quantities of heat are generated by the internal combustion engine; the gases are lost through the exhaust system while the heat is radiated by the engine block, the radiator, and the exhaust system.

Procedure

1. Before the activity, obtain a model or toy car. Best would be one that opens to show the engine, or that runs on batteries, lights up, etc. (Best of all, arrange for students to examine an actual car, look under the hood, etc.)
2. Prepare a transparency of the student sheet, and get felt pens in the same colors as the students' colored pencils or crayons.
3. Begin by using the model (or real) car as the basis for a discussion about the kinds of energy we find in a car.

Ask: What makes a car run? (gasoline, fuel) Where is it? What kind of energy is that? (chemical energy) What do we have to do to the fuel? (burn it) How does that make the car go? (engine converts heat to mechanical energy) Where is the engine? How does the energy get from the engine to the wheels? (transmission and drive shaft) Where are they? What runs the lights and the radio? (mechanical energy makes electrical energy) Does the engine get hot when the car runs? (yes) Is that heat useful? (most is wasted energy) How does the car get rid of waste heat? (through the exhaust system and the radiator) Where are they? What else comes out of the ex-

haust system? (waste fuel and products from burning fuel).

4. Ask: How many kinds of energy do we have in a car? (chemical, heat, mechanical, electrical --- also light, sound) Which are the main ones? (the first four).

Write on the board:

chemical energy

heat energy

mechanical energy

electrical energy

Have students choose a color to represent each form of energy. Write the color next to the energy form.

5. Distribute the How is energy changed in a car? and the Energy in a Car sheets. Have students copy the color key from the board.
6. Read the introduction and the steps of the activity together. With the overhead transparency, discuss the fuel tank first as an example.

Write fuel tank in the appropriate box, and color the box with the color for chemical energy. Use the same color for the shaded area of the car where the fuel tank is.
7. Follow the same procedure for the other parts, encouraging students to tell you what happens at each part and what forms of energy are present. (As you will note from the key, more than one form is present in some parts.)
8. After completing the Energy in a Car sheet, have students answer questions A - G. Discuss the answers as a group. Point out that people want cars that get good gas mileage. This means cars that get more mechanical energy and less waste heat and waste fuel. It also means cars that weigh less, since it takes more fuel to move more weight.
9. If possible, have the class examine a real car again as a review of the activity.

Materials

3. model or toy car, or a real car.
4. chalkboard
5. How is energy changed in a car? and Energy in a Car sheets, pencils, colored pencils (4 colors)
6. transparency of student sheet, overhead projector and screen, colored felt pens (black and 4 colors - same as students')

Estimated Time for Activity

1 hour

Typical Results

The teacher will wish to simplify or add to this activity, depending on his/her own knowledge and the ability of the students. Allowing students to examine a real car as part of the discussion will add greatly to the motivational value of the activity.

Students should complete a properly labeled diagram showing the primary energy transformations that take place in an automobile. Checking their responses to the questions concerning the energy conversions will likely reveal some misconceptions that the teacher may wish to review and correct.

Safety Notes

3. If a real car is used to start discussion, make sure that it is parked in a safe area, and that it cannot be started by mistake or as a prank.
6. When using the overhead transparency, position students so all can see and read the projection easily.

More Ideas

Go on to discuss the following points:

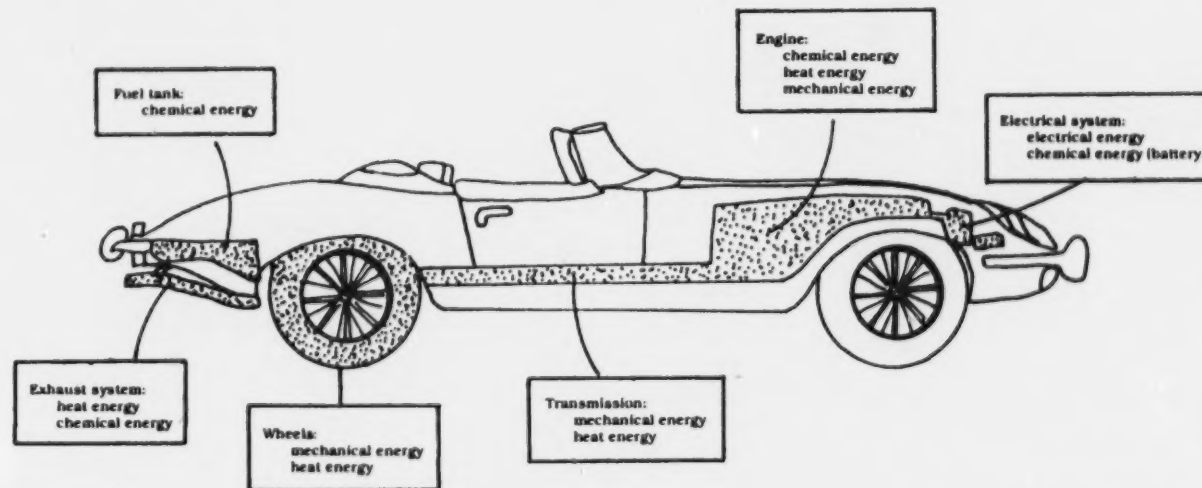
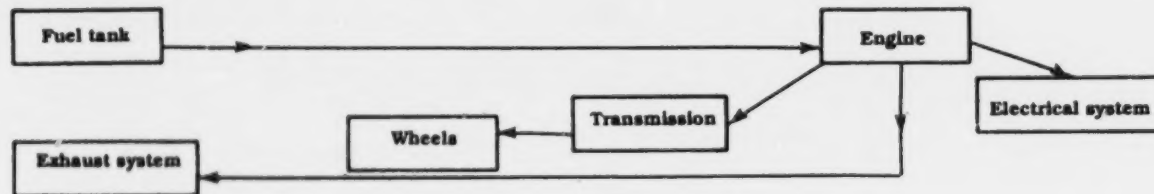
- a. Excess heat which must be eliminated is produced in the internal combustion engine; hence the need for a cooling system and the radiation of heat by the engine and the exhaust system.

- b. Friction among the parts of the automobile and within the engine, between the tires and the road, and between the body and the air, and/or improper combustion, contribute to the inefficiency of the automobile. Reducing friction and improving combustion improve gas mileage and extend the life of the car. This in turn reduces the demand for the resources necessary to replace the car.
- c. Gaseous emissions from the automobile engine and exhaust system, as well as particulates discharged in the exhaust, constitute about half of the pollution added to our atmosphere each year.

This contributes to the formation of acids within the atmosphere which cause physical damage to property (paints, metals, cloth, and stone) and nature (lakes and forests), and affect the health of those with respiratory problems. Particulate emissions produce corrosive dirt and grime which pollute the environment and can affect the health of individuals.

Have students collect information on energy conservation in transportation. Make a bulletin board of the most important conservation points, contrasted with car advertisements from magazines.

Teacher Key



How is energy changed in a car?

A car is a machine with many parts that help with one job: changing the chemical energy in gasoline to the other kinds of energy that run the car. In this activity you'll hear about

chemical energy	the fuel tank
mechanical energy	the engine
electrical energy	the electrical system
heat energy	the transmission
	the wheels
	the exhaust system



Materials

Your Energy in a Car worksheet, 5 pencils
or crayons (4 colored and 1 black)

Steps

1. Your teacher will show you a chart of how energy is changed in a car.
2. As the teacher explains each part of the car, label the box on your own chart with the name of the part, in black.
3. After the teacher explains each part, color that box on your chart with the color for the kind of energy you may find in that part of the car. (You may need to use more than one color).
4. Next go the drawing of the car. Find the shaded part of the car, and color the shaded part that goes with the box you just colored.
5. Repeat Steps 2,3, and 4 for each part of the car.

6. After your sheet is finished, answer the following questions.

- A. How is the chemical energy in gasoline converted to mechanical energy in the engine?

- B. Is all the energy in the gasoline converted to mechanical energy?

Explain. _____

- C. How does the mechanical energy of the engine get to the wheels?

- D. What escapes through the exhaust system?

- E. What kind of energy does the engine produce besides mechanical energy for the wheels?

- F. Where does that other kind of energy go?

- G. What does the electrical system of the car do?

Student Sheet

Key

chemical energy



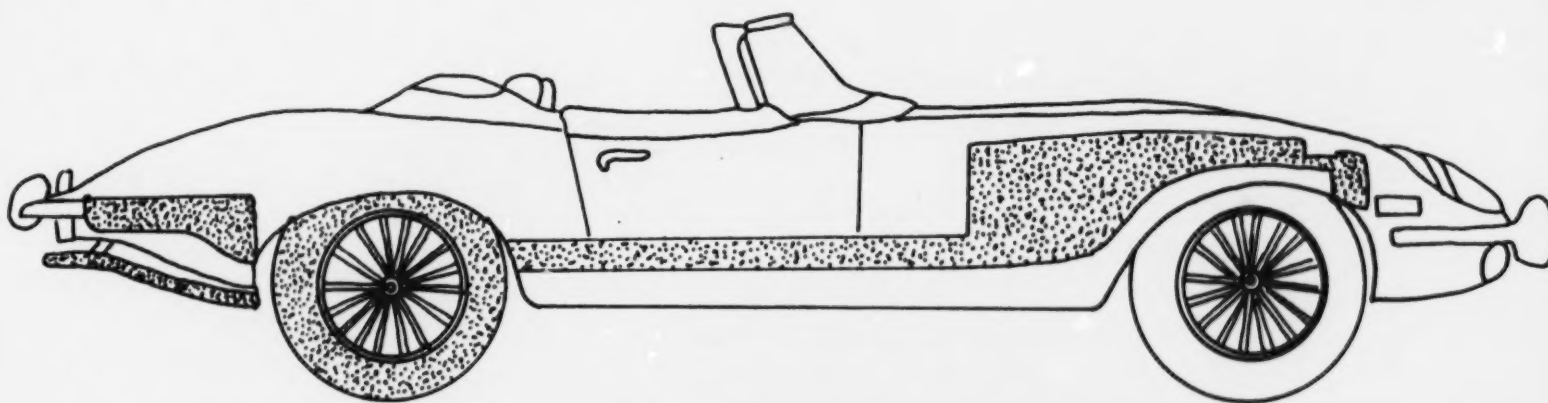
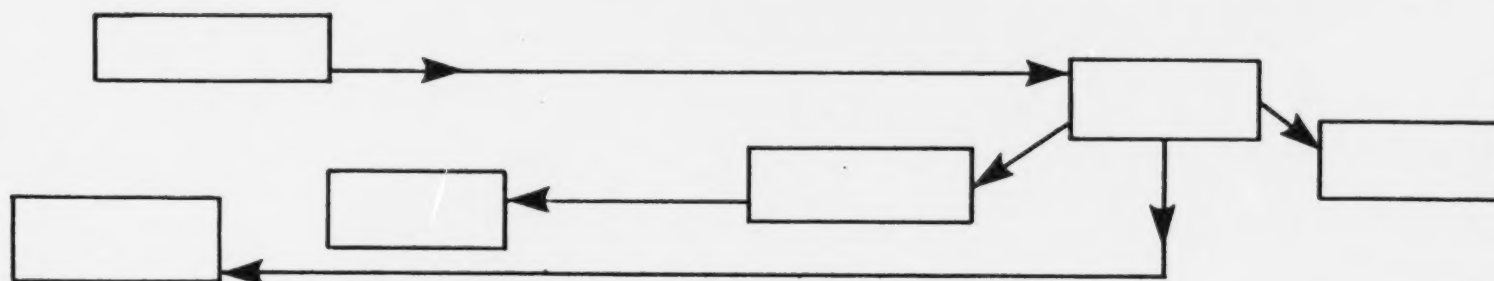
electrical energy



mechanical energy



heat energy



Energy in a Car

8. Question: How can we generate electricity?

Purpose

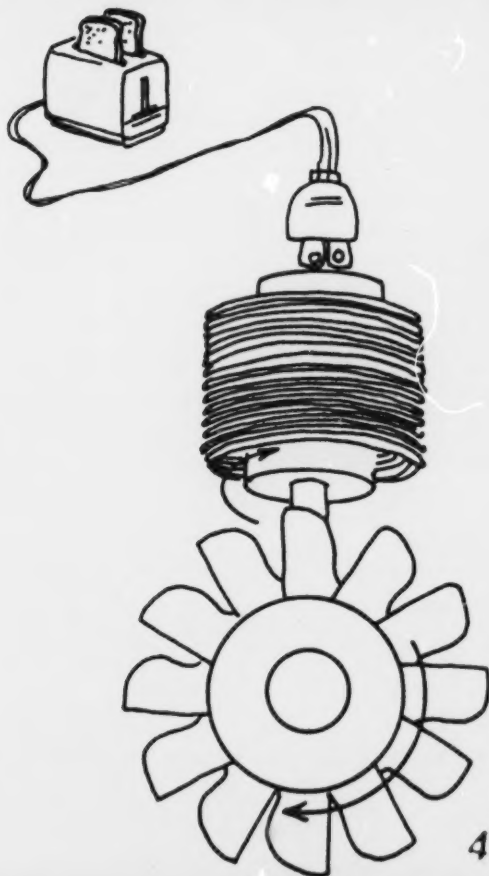
To make students aware of the basic parts of an electric generator, and to allow them to experiment with generating a current.

Introduction

Students will use a magnet and a wire coil to see how electricity is produced. They will experiment with generating an electric current in the wire and detecting it with an electric meter.

Background

Most electricity is commercially produced using large generators. The generator



Understandings

Electrical energy can flow through circuits.

A magnet moving within a coil of wire will produce a flow of electrical energy in the wire.

Skills

Observing
Manipulating materials
Inferring
Generalizing
Formulating hypotheses

Attitudes

Welcoming the unknown or the ambiguous.

Valuing systematic investigation.

consists of two parts: the armature, which is a large coil of wire, and magnets which are usually electromagnets. By moving the coil of wire through the field of the magnets, a current (a flow of electrons) is induced (produced) in the wire.

It does not matter whether the coil of wire moves through the magnetic field or whether the magnetic field moves over the wire. The current is always produced in the wire.

As you can see, something has to turn the coil or the magnet. Without energy to do that turning, no electricity can be produced. In an electric generating plant, that energy usually comes from a large windmill-type apparatus called a turbine. The turbine has many blades attached to a shaft.

The turbine is usually spun by hot, expanding steam from a boiler. And the steam is produced by burning fossil fuels or

using a nuclear reaction to heat water. However, running water (hydropower) can also be used to spin a turbine. So can wind.

When the turbine turns, its shaft turns. The shaft is attached either to the armature (coils) or to the magnet, and turns it, generating electricity.

In order for the current to flow, there must be a complete circuit connected to the wire that breaks the magnetic field. In other words, the end and the beginning of the wire are connected, making a complete loop. The electrical current that is produced is a flow of electrons, in the wire, which can be utilized in various ways. If the end and the beginning of the wire are connected through a radio, for example, the radio will play!

Procedure

1. This activity can be done either as a demonstration or by small groups or individual students using the student sheet. Even if a demonstration is used, allow students to do the manipulations of the magnet and coil.
2. Coil the wire around the tube. Be sure there is enough wire on each end to connect to the galvanometer. (See diagram.) Both ends of the wire must be connected for a complete circuit.
3. Introduce the idea that an electric current is a flow of electrons. A magnet can pull tacks or nails; it can also pull electrons.
4.
 - a. As a demonstration: Ask students to describe what you have. Hold up the magnet and the coil and point out the meter.
 - b. Say that magnets and wires are used to produce electrical currents. Ask: How do you think we might use these to produce a current? Try the ways that are suggested.
- c. If no one suggest passing the magnet through the coil, suggest that and try it. The needle should move readily when this is done.
- d. Ask: Do you suppose it makes any difference if we move the magnet in different directions?

Try it. The largest current will be produced when the magnet moves perpendicular to the coils.
- e. Ask: Are there any other things you can think of that might change the amount of current produced (as shown by the galvanometer deflecting)?

Try some of the suggestions.
- f. Have the students verbally summarize what they have found out. Go over the worksheet questions.
- g. Have the students write a description of how electricity is produced using a magnet and a wire. Include a diagram which shows how the magnet moved to get the most current.
5. Discuss electrical safety, and go over the Electricity Safety sheet. Emphasize the difference between the weak electric current they have generated in class and the powerful current that comes to their homes from electric generating plants.

Materials

1. For each group of students:

100 cm of bare copper wire; bar magnet; electric meter (i.e., galvanometer or milliammeter,

available from most junior or senior high science departments); hollow tube such as a toilet paper roll; student sheet, How can you make electricity with a magnet?

5. Electricity Safety sheet

Estimated Time for Activity

one 45-minute period

Typical Results

Any time the magnetic lines of force are broken by a wire a current will be produced in the wire. Various factors will affect the magnitude of the current. Increasing the number of coils or moving the magnet faster should induce a stronger current.

Safety Notes

Caution students that the electric meters are fragile. If results are erratic, let students experiment more to iron out the inconsistencies.

It is not possible to receive an electric shock from the coil, since the current is too weak.

More Ideas

Try constructing a turbine generator, using some form of energy (perhaps wind or water) to do the turning.

Investigate how an electric motor works and build a simple one.

How can you make electricity with a magnet?

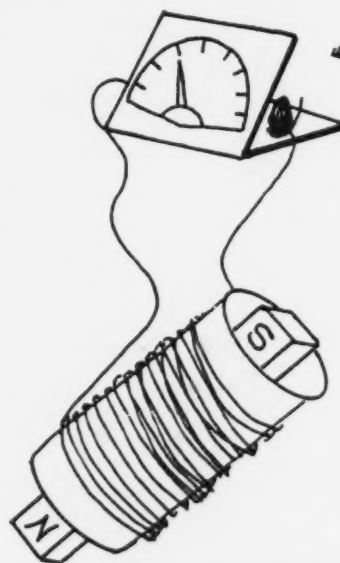
Of course you know how a magnet can pick up small metal objects. You can actually make a tack jump to the magnet by holding them close together.

Magnetism is a form of energy. It can push or pull things. It can even push or pull some of the tiny particles that make up matter: electrons. And when you push or pull electrons, you get electricity.

Let's try making electricity with a magnet.

Materials

100 cm of bare copper wire
1 bar magnet
1 electric meter
1 cardboard tube



Steps

1. Wind the wire around the tube about 20 times.
2. Connect both ends of the wire to the meter, as shown by your teacher.
3. Take the magnet and move it near the coil but not through it. Observe the meter.
4. Move the magnet in various directions around the coil.
5. Move the magnet through the coil, back and forth. Make more than one trial doing this. Try moving the magnet at different speeds. Move the coil over the magnet, keeping the magnet still.

Now answer the questions below:

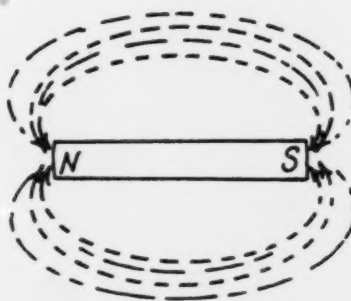
1. In which step did the meter move the most?

2. When the meter made the greatest movement, in what direction were you moving the magnet?

3. Was there a difference between moving the magnet through the coil, or moving the coil over the magnet?

4. Was there a difference when you moved the magnet faster?

5. The lines of force on a magnet would look something like this (If we could see them).



What happened to those force lines when you moved the magnet inside the coil?

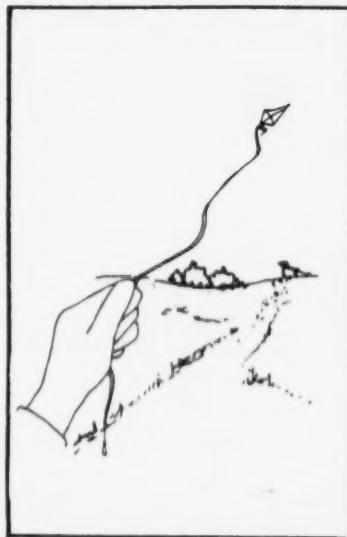
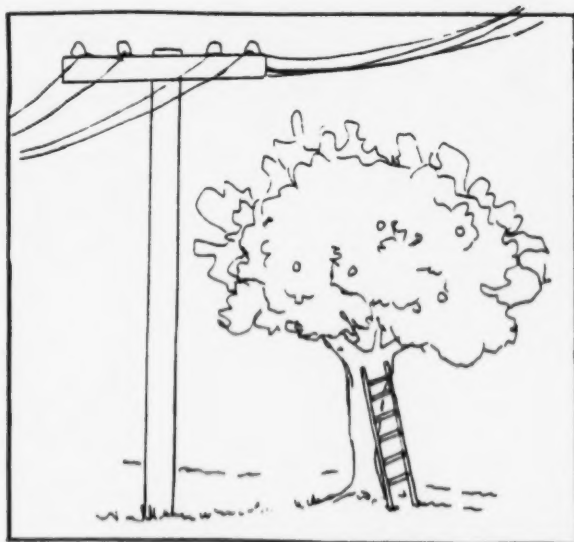
6. Can you figure out some way that you could make the magnet spin really fast inside the coil?

Electricity Safety

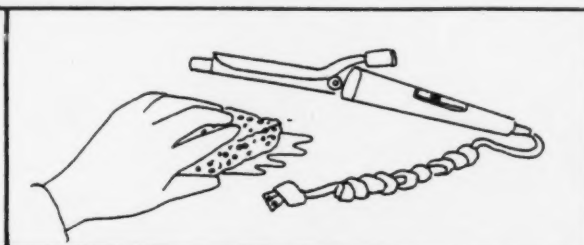
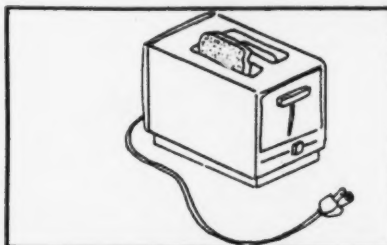
Your small magnet and coil couldn't give you a shock. The electricity they make is too weak.

The electricity that comes to your home is made by a huge magnet and coil -- the size of a house. It can be very powerful -- and dangerous -- if you don't know how to use it safely.

Learn the rules of electricity safety.



Avoid contact like climbing trees or ladders, flying kites, shooting or throwing things near electrical transmission lines.



Unplug an appliance before you check it for problems -- a worn cord, a stuck piece of toast.

Keep water away from electricity, including electrical fires. And if you are wet, stay away from appliances which use electricity.

Stay away from electric substations, power poles, transformers, or power lines.

9. Question: How do electric generating plants produce electricity?

Purpose

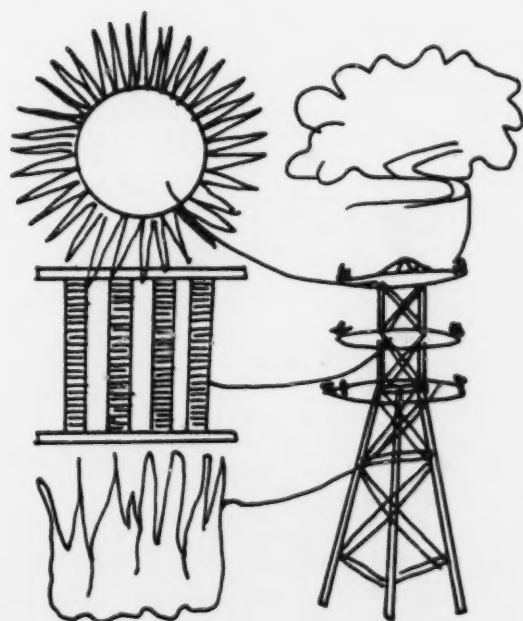
To show students that a variety of energy sources can be used to produce electricity, and to illustrate the process by which this is done.

Introduction

Students will be introduced to some of the ways that electric generating plants produce electricity. The students will make a flip book which will help them to visualize the processes that go into producing electricity.

Background

An electric generating plant makes electricity by using a generator: coils of wire in which a magnet is rotated. The turning of the magnet induces an electric current in the wire.



Understandings

Material and energy can be transferred several times within a complex system through a series of interactions.

Material and energy may be changed in form more than once as interactions occur within a complex system.

Power plants make electricity with generators which need energy to turn them. Energy can be supplied to the generator in a number of different ways.

Skills

Classifying
Replicating
Identifying variables
Developing vocabulary
Using cues
Acquiring information

Attitudes

Valuing the practical and technological.

Wanting to know conventions useful in understanding the natural world.

What makes the magnet turn? Some source of energy must be used. Usually the generator is attached to a turbine, a large windmill-like wheel with many blades splayed out from a shaft. When a force is exerted against those blades, the turbine turns. Its shaft turns the magnet, and electricity is generated.

The force to turn the turbine may be hot, expanding steam or another gas. It may be flowing water or wind.

The commonest type of generating plant today uses a steam turbine generator. A fossil fuel (coal, oil, or natural gas) is burned to heat water to make steam. A fission reaction of nuclear fuel can also be used as a source of heat for making steam. Solar power towers, now only in the experimental stage, produce steam by using mirrors to concentrate sunlight on a boiler. Geothermal energy, steam from deep in the earth, is also used in a few places to generate electricity.

A similar kind of generator uses the hot gases that result from burning oil, coal, or natural gas. No water or steam is involved, so it is called a gas turbine generator.

A hydropower or water turbine generator has turbines built into a dam, with stored water behind it. Water is channeled down through the dam to the turbines, where the force and pressure of the water spins them.

With a wind-powered generator, the turbine is the windmill's rotor. As it spins, it turns a generator mounted on top of the windmill's tower. Power lines carry the electricity from there to the point of use.

Procedure

Activity 8 is a prerequisite for this activity, since it is necessary for students to understand that rotating a magnet in a coil generates electricity.

1. Start the activity with a discussion of how electricity is generated: magnet and coils.

Ask: What moves the magnet through the coils? What if you wanted to generate a lot of electricity? How could you rotate a large magnet in a large coil?

2. Introduce the idea of the turbine -- like a pinwheel -- something that will turn if we blow on it.

Ask: How could we make something like a pinwheel turn? What kinds of energy could we use? Could we attach a shaft to a pinwheel so that it would turn a magnet in a coil?

3. Talk about the 4 main ways to turn a turbine:

- with steam
- with other hot gases
- with flowing water
- with wind

Explain that when steam or any other gas is hot, it tries to expand, so it has a force or push that can be used to turn a turbine.

4. Distribute student sheets. Have students cut the FLIP BOOK pages along the cutting lines, and discard the shaded sections. Have them stack the pages in order, and staple at the left hand margin.
5. Discuss each way of producing electricity, starting with page 1. Have students discuss and decide which Electric Generating Plant Piece should go in each space. Cut and glue the pieces in place. (The lines between the boxes provide clues to which boxes go where.)
6. Go on to the next page. NOTICE that when you complete page 7, you have completed the last part of all the other pages.

7. When the books are completed, discuss:

What is the same about all the different ways of producing electricity?

What is different?

How is most of our electricity made?

How much of our electricity (page 1 and page 5) comes from fossil fuels altogether?

8. Remind students that although a small magnet and coil can't give them a shock, a big one can. Review their Electricity Safety sheet, from Activity 8.

Materials

4. student sheets:

Generating Electricity flip book pages,
Electric Generating Plant Pieces,
scissors, pencils, stapler, glue

Estimated Time for Activity

1.5 - 2 hours

Typical Results

Some difficulty may be encountered in getting the flip books together. Once that is accomplished, the understandings follow easily. You may wish to review Level II, Activity 10, which shows how electricity gets to our homes.

If the flip book is too challenging for some students, the teacher may wish to delete some pages, or key the power plant pieces by letter for easier identification.

Safety Notes

None

More Ideas

Contact the electric company that serves your school and arrange for a class field trip to the nearest generating plant.

Write to the electric company for literature on electric safety and how electricity is generated.

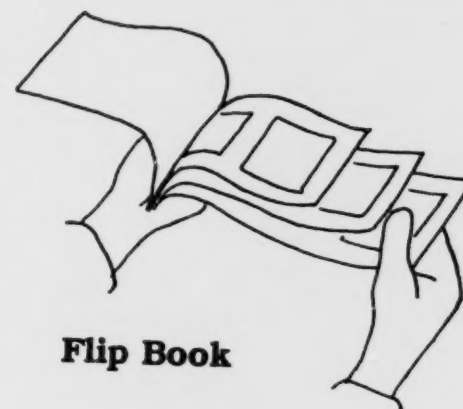
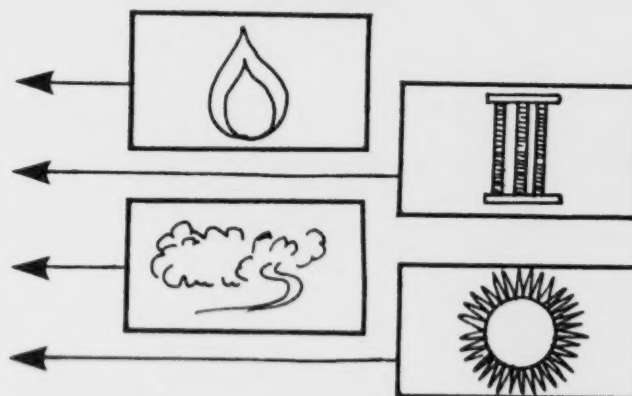
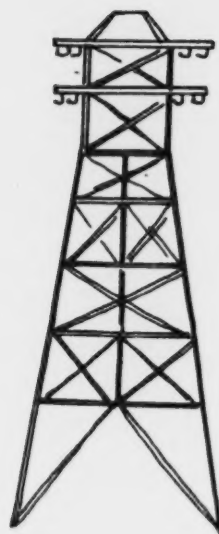
Make models of different kinds of generating plants.

To _____ Folks,

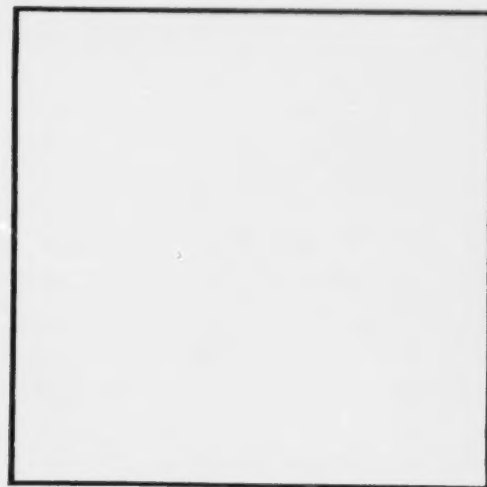
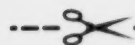
This week the class is learning about HOW ELECTRICITY IS GENERATED. The class made flip books to show seven different ways that other kinds of energy are converted to electricity.

They also learned some of the important rules of ELECTRICITY SAFETY. Please review them with your child.

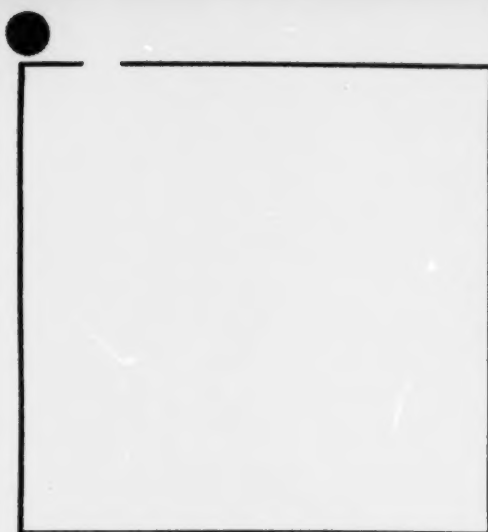
Generating Electricity from Many Sources of Energy



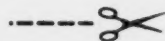
Flip Book



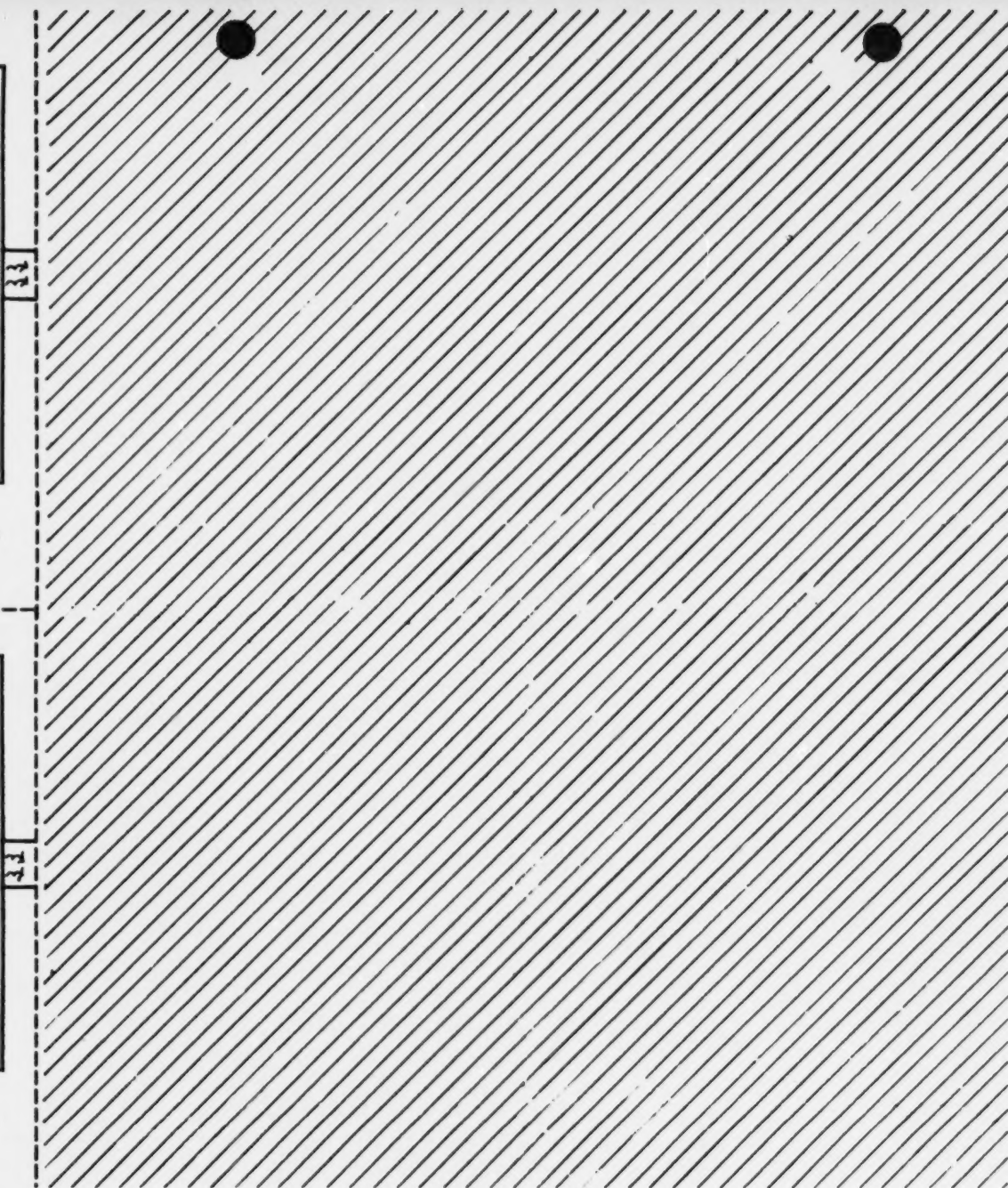
1. We burn coal, oil, or natural gas to make steam to produce 72% of our electricity.

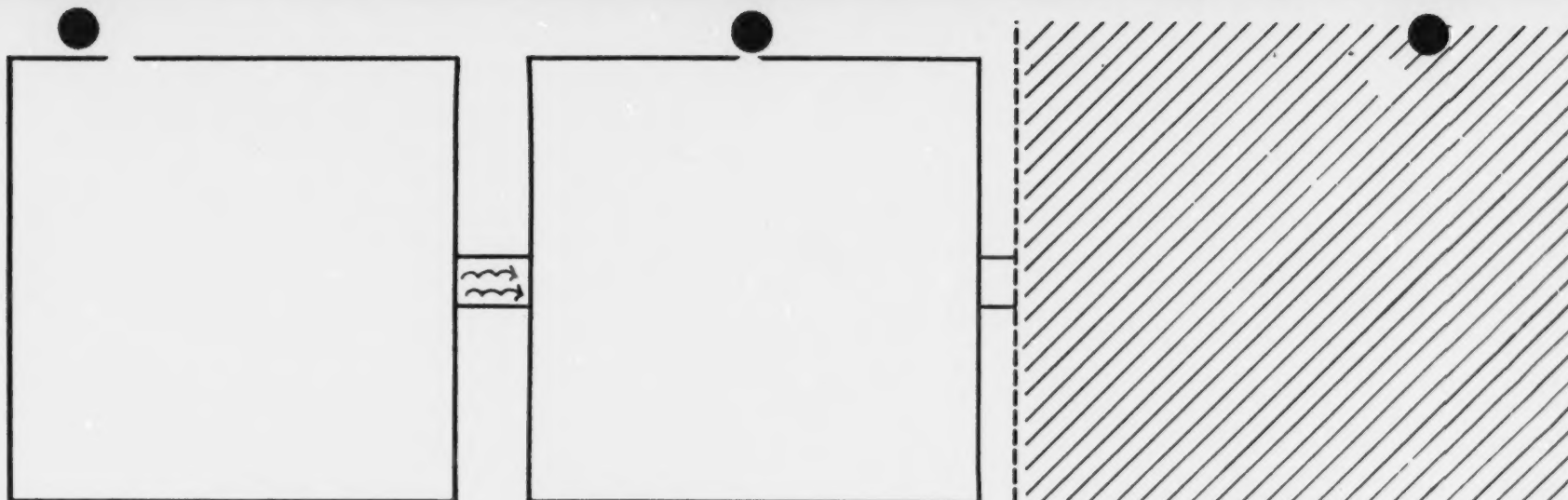


2. We use nuclear fission to make steam to produce 12% of our electricity.

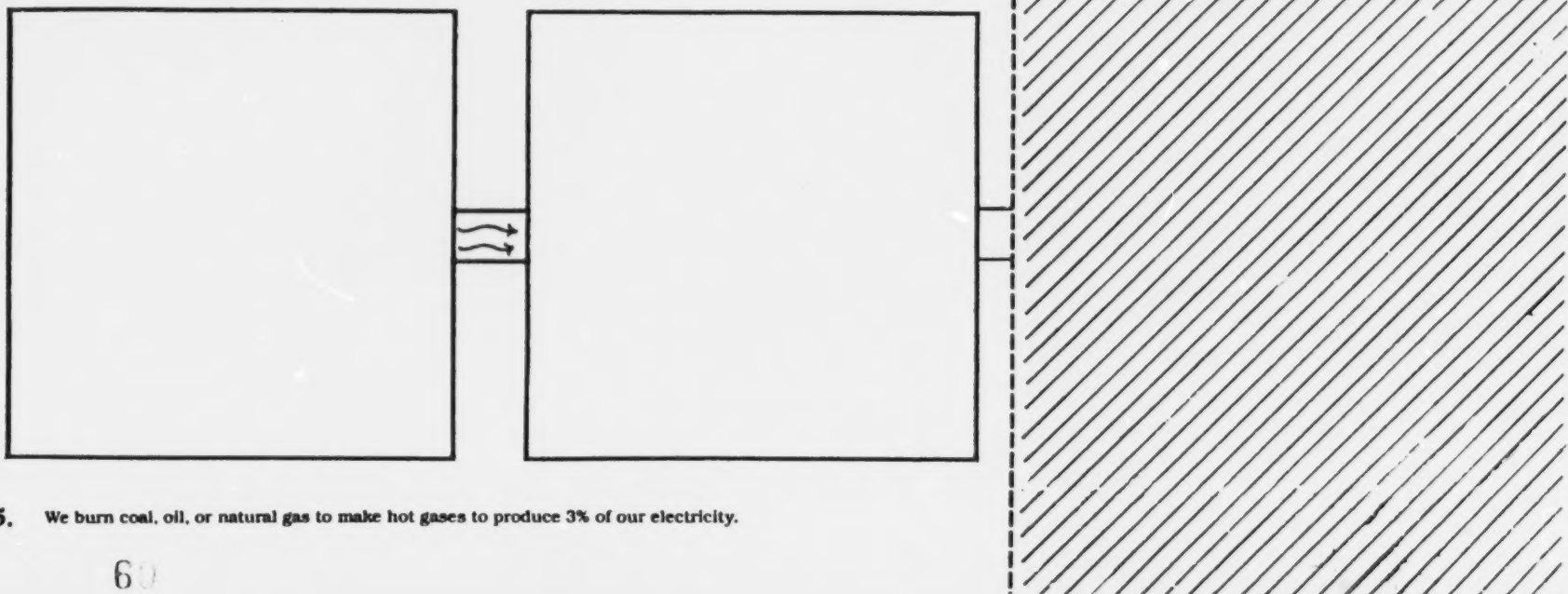
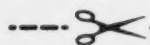


3. We can concentrate sunlight to make steam, but this is still experimental.

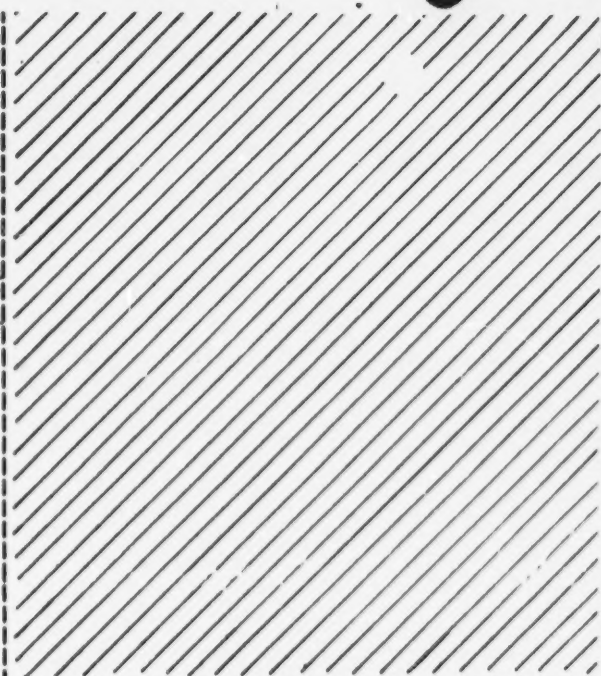
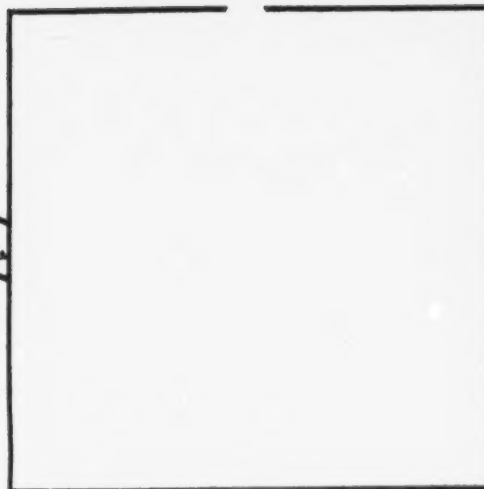
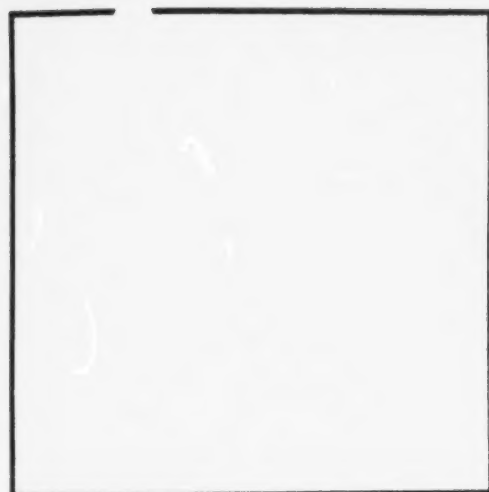




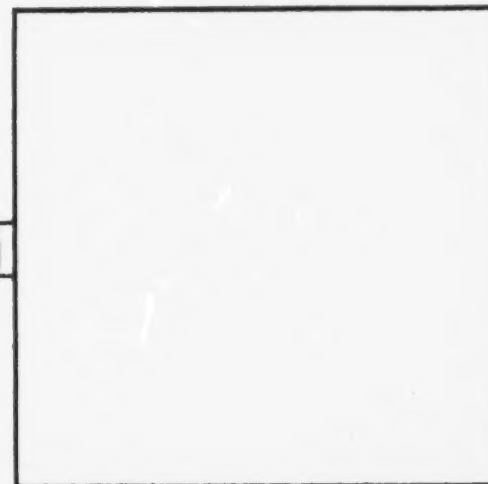
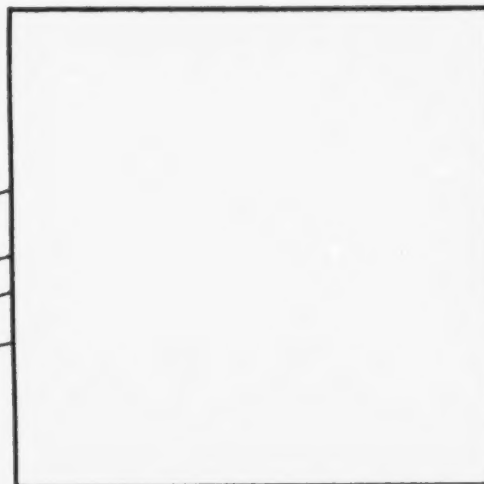
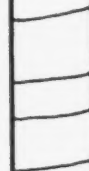
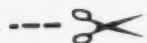
4. We get steam from beneath the earth's surface to produce a small amount of electricity.



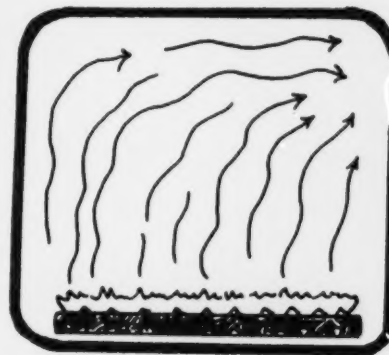
5. We burn coal, oil, or natural gas to make hot gases to produce 3% of our electricity.



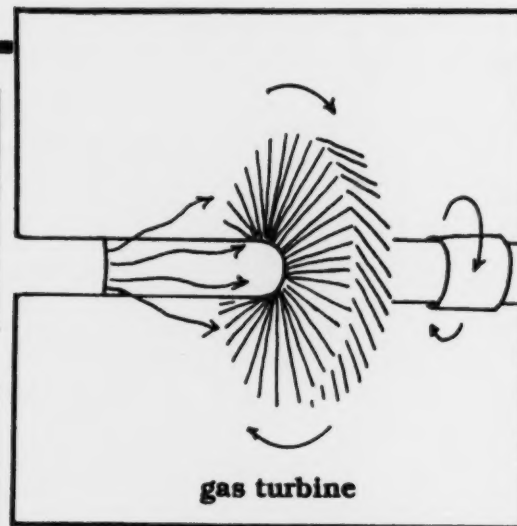
6. We dam up water to turn turbines to make 13% of our electricity.



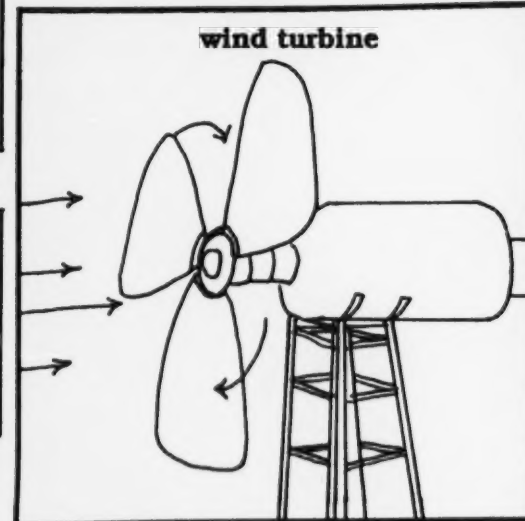
7. We use the wind to turn turbines to produce a very small amount of electricity.



Fossil fuels → hot gases

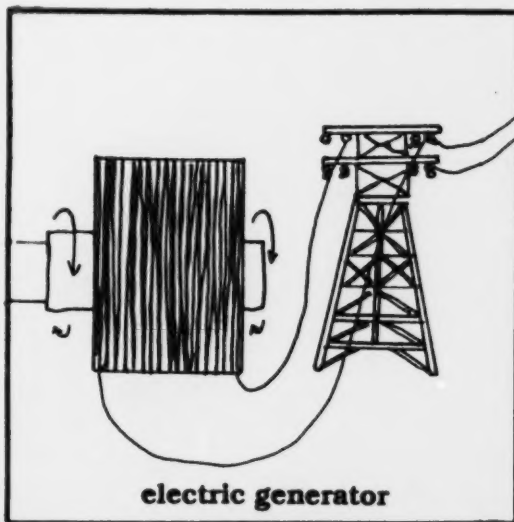


gas turbine

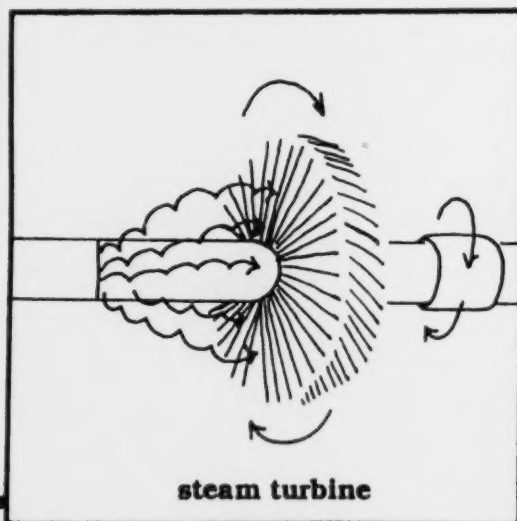


wind turbine

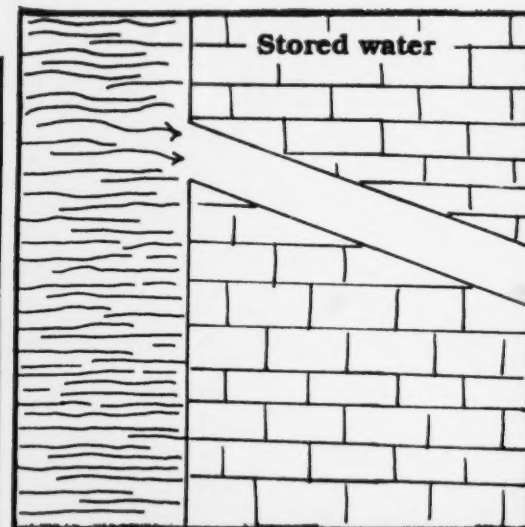
Generating Plant Pieces



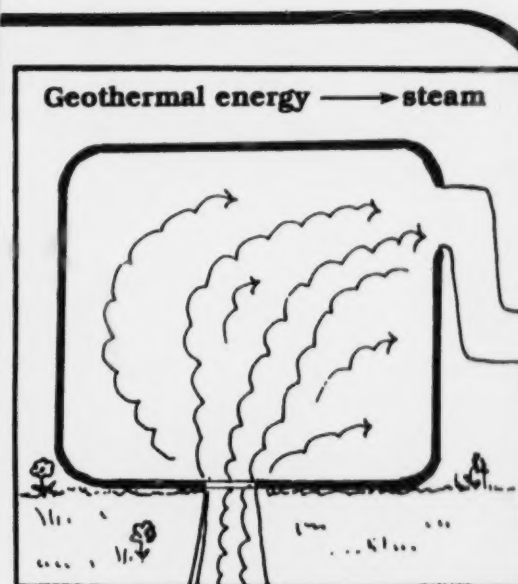
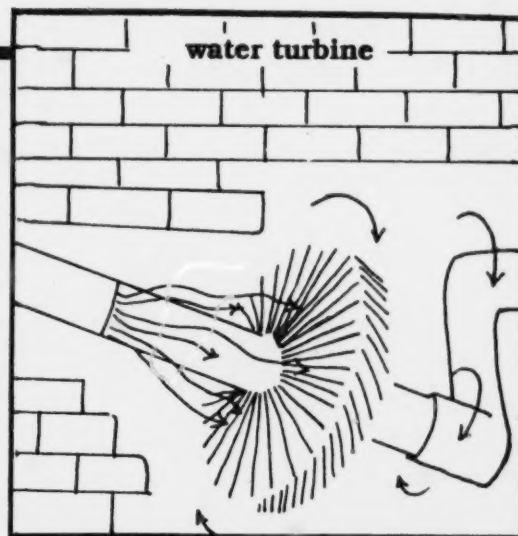
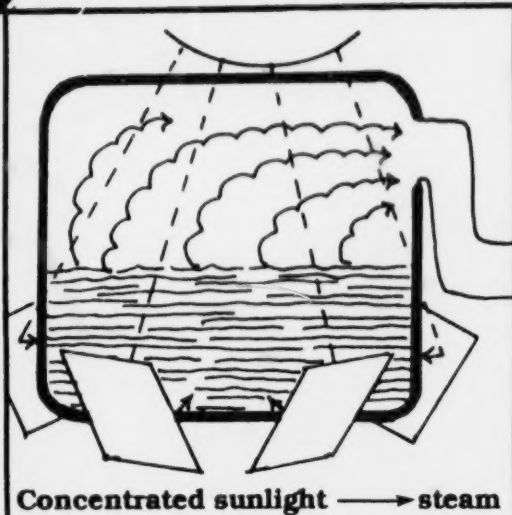
electric generator



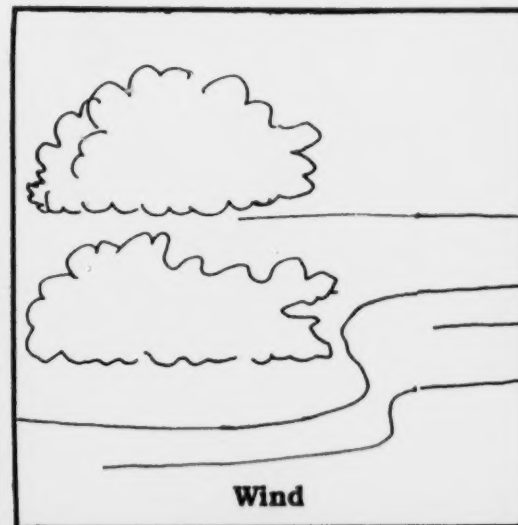
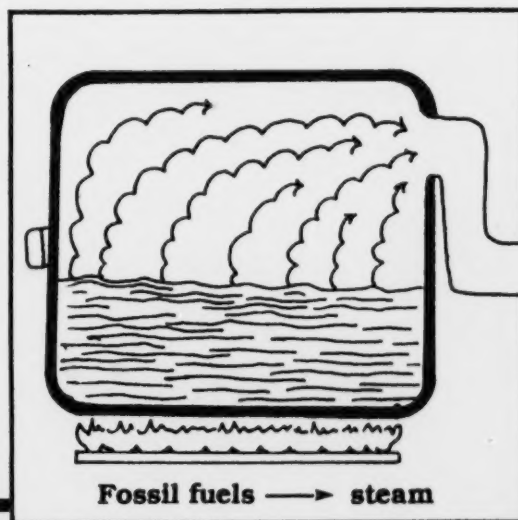
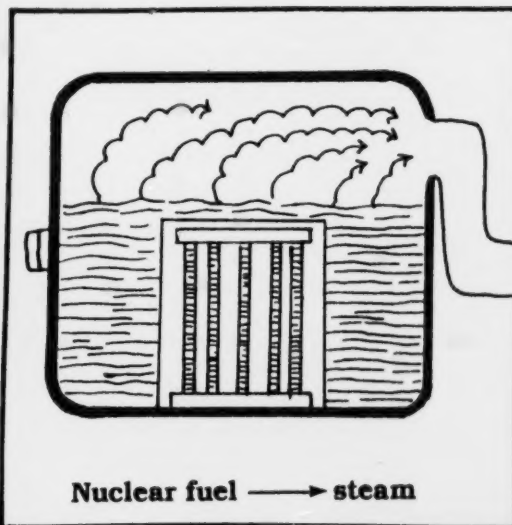
steam turbine



Stored water



Generating Plant Pieces



10. Question: How is a battery made?

Purpose

To make students aware that chemical energy can be converted into electrical energy in a battery.

Introduction

Using dissimilar metals (zinc and copper) and an acid (vinegar), students will make simple batteries and measure their electrical output using milliammeters. Comparisons will be made between these batteries and commercial flashlight batteries.

Background

Batteries are devices that convert "chemical" energy to electrical energy. By using substances such as metals or carbon that have different chemical properties and an acid that will allow the movement of electrical charges, an electric current can be produced.

A common misconception is that batteries store electrical energy. This is not

Understandings

A complete circuit will enable electrical energy to flow from a battery through a conductor. The amount of energy transferred during a flow of electrical energy depends on the source and the object to which it is applied.

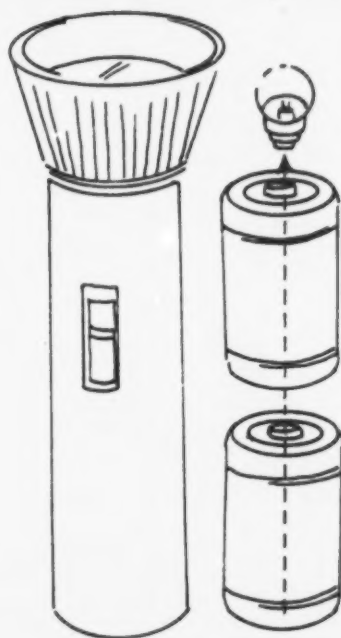
Skills

Manipulating materials
Replicating
Observing
Recording data
Acquiring and communicating information

Attitudes

Valuing resourceful and innovative means to solve practical problems.

Valuing collaborative efforts.



strictly true. They store "chemical" energy which can be released during a chemical reaction. As part of this process, electrons are freed to move and by providing a path for them to move along, an electrical current is produced.

The battery that the students make in this activity uses two dissimilar metals, copper and zinc, and acetic acid (vinegar). Each of the metals reacts with the acid and electrons are freed. By connecting a wire (conductor) between the pieces of metal and putting a device (milliammeter) that detects the current in the circuit, a working battery is made.

Procedure

1. Introduce the idea of a battery. Some students will have used them, so you can relate what batteries do to their experiences.

2. Discuss, in a general way, how a battery works. The background section of this activity explains this.
3. Introduce the making of a battery. Hand out the student sheets and use them as the outline for the introduction.
4. Show the materials to be used and discuss the safety aspects of the activity. These are listed in the "Safety Notes" section.
5. Show a sample set-up and point out how the wire connections are made. See the section of this activity that provides a diagram and instructions.
6. Divide the students into group of 2 or 3 and have 1 student from each group get the materials and take them to his/her work station.
7. Have the students construct their battery and circuit, complete the steps listed, and record the data requested.
8. Now have students connect flashlight batteries to their milliammeters. Ask them to compare the strength and duration of the current to that produced by their previous batteries.
9. Using the completed student worksheets, compute the class average time for the student-made batteries and discuss the questions in the student section.

Materials

3. student sheets:

Let's make a battery! and
Diagram and Directions

4. for each team:

pint jar or 400 ml beaker; cardboard top with 2 slits; 1 strip of zinc metal; 1 strip of copper metal; sandpaper or steel wool; vinegar; 1 milliammeter (most junior high school or high school laboratories would have this)

8. flashlight batteries

Estimated Time for Activity

1 hour

Typical Results

The student-made batteries will produce enough current to move the needles of the milliammeters. The strength and duration of the current produced by the flashlight batteries will be greater and longer.

Safety Notes

7. The acetic acid (vinegar) is very dilute and will do not harm to skin or clothing. The electrical current that is produced is so small that it is impossible to get a shock from it.

However, some safety tips might be taught. They can be summarized as follows:

When working with any chemical be careful not to spill it, get it on your skin or in your eyes. (Goggles are best for this.) Be careful of electrical currents. Although this one is small, stronger currents can cause injury.

More Ideas

Obtain a lemon. Roll the lemon between your hand and a table top to release the juices. Cut 2 slits in the lemon, one at each end. Insert a clean penny in once slit and a piece of aluminum foil in the other. Connect the wires and a milliammeter to the penny and foil and see what happens.



Find out how a car battery works.

Find out about the environmental effects of producing and disposing of batteries.

Let's make a battery!

One way to produce electricity is to move a magnet through a coil of wire. That is how the electric generating plants make electricity.

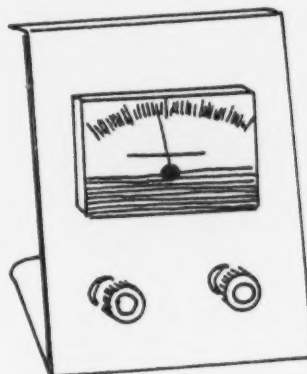
But there is another way to make electricity: with chemicals. When you bring two chemicals together, one may start to take electrons from the other. If you then run a wire between them, the electrons can travel in a complete circle, making an electric current. That is how a battery works, and you are going to make one right now!

After this activity, you should be able to give answers to these questions:

How does a battery work?
What parts does a battery have?
How long does a battery last?

Materials

1 pint glass jar or 400 ml beaker
cardboard top with two slits cut in it
1 strip of zinc metal
1 strip of copper metal
sandpaper or steel wool
2 pieces of copper wire
1 milliammeter
vinegar

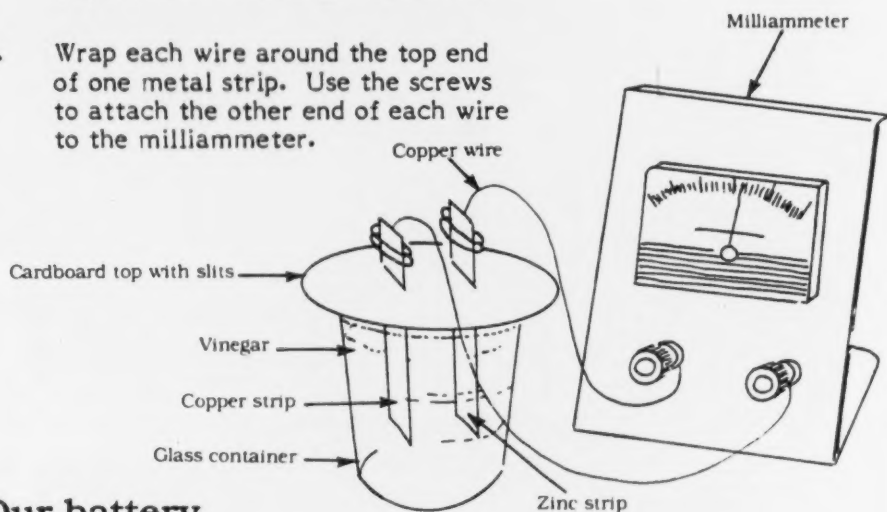


Steps

1. Set up the apparatus as shown by your teacher. But do not put the vinegar in the glass container yet.
2. Have your teacher check your set-up. When told to, pour enough vinegar into the container to cover more than half of the metal strips.
3. The milliammeter needle should move as soon as you put the strips into the vinegar with the wires connected.
4. Immediately record the time the needle first moved. Record the time in the labeled space.
5. Check the apparatus every so often, as directed by your teacher, until the needle returns to zero. Record the time this happens.
6. Subtract the beginning time from the ending time and determine the length of time the milliammeter was receiving current.

Diagram and Directions

1. The slits in the cardboard should be very narrow so that the metal strips are held suspended in the vinegar.
2. The metal strips should be cleaned, preferably with steel wool or sandpaper, before starting the activity.
3. Wrap each wire around the top end of one metal strip. Use the screws to attach the other end of each wire to the milliammeter.



Our battery

Beginning time	Ending time	Total time the battery lasted

The class average time _____

1. How does your group's time compare to the class average?

2. Explain how the battery works.

3. Based on the class average time, how do these batteries compare to a flashlight battery?

4. What are the good points and bad points of this kind of battery?

11. Question: How much energy and money do appliances use?

Purpose

To give students practice in using energy units, and to make them aware that using energy costs money.

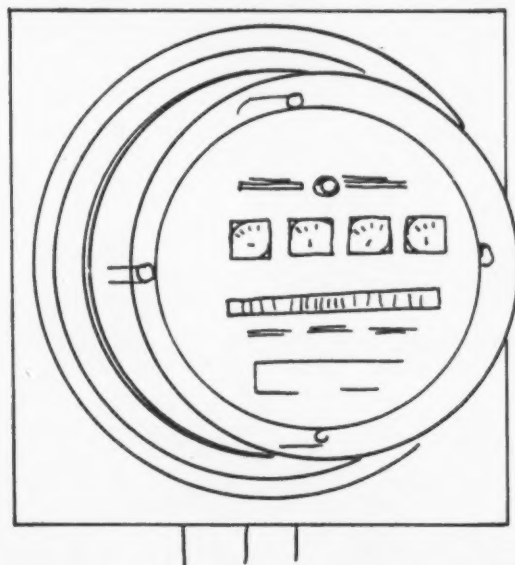
Introduction

Students will be shown how to calculate the cost of running an appliance. They will gather data on home appliances and calculate the cost for running them, using a computer program or their own arithmetic skills.

Background

Electrical energy is used to run most of our appliances. The utility companies must measure the amount of electricity used in order to be able to bill us.

The most commonly used unit of measurement for electricity is the watt or its multiple, the kilowatt. Electrical energy use is monitored through an electrical meter that reads directly in kilowatt hours (kilowatts used for the hours measured). The rate paid the utility is quoted in a price per kilowatt hour.



Understandings

Energy must be added to a complex system to maintain the interactions.

Skills

Using numbers and cues
Recording data
Interpreting data
Generalizing

Attitudes

Wanting explanations which lead to accurate predictions.

Valuing the practical and technological.

The appliances found in a home are usually labeled by the number of watts of electrical power they use. Sometimes the label only lists the number of amperes (amps) and volts used. (The amp is the actual current of electrons, while the volt is the force behind it.) To calculate the number of watts the appliance uses, you simply multiply the amps by the volts listed.

To then calculate the number of kilowatts consumed, you divide the number of watts by 1000. To determine the number of kilowatt hours used you multiply the number of kilowatts by the number of hours the appliance ran.

Example:

An electrical motor is labeled to run on 110 volts and 10 amps. The motor is run for 5 hours. How many kilowatt hours of electrical energy are consumed?

step 1 - number of watts = number of amps x number of volts
 number of watts = 10 amps x 110 volts
 number of watts = 1100 watts

step 2 - number of kilowatts = number of watts/1000
 number of kilowatts = 1100 watts/1000
 number of kilowatts = 1.1 kilowatts

step 3 - number of kilowatt hours = number of kilowatts x number of hours run
 number of kilowatt hours = 1.1 kilowatts x 5 hours
 number of kilowatt hours = 5.5 kilowatt hours

To calculate the cost of running the motor for this period of time, you multiply the cost per kilowatt hour by the total number of kilowatt hours consumed. The cost for your area can be found on your electrical bill. Suppose electricity costs \$.10 per kilowatt hour in your area.

step 4 - cost for using appliance = number of kilowatt hours x cost per
 kilowatt hour in your area
 cost for using appliance = 5.5 kilowatt hours x \$.10
 cost for using appliance = \$.55

Using this technique, the cost of running specific electrical appliances can be calculated if the time they run can be measured or estimated.

Procedure

How you choose to do this activity will depend on how well your students can handle decimals.

You have three choices:

using the computer program (easiest)
using a calculator
having students do their own arithmetic
(most difficult)

1. Discuss the concept of the measurement of electrical energy.
2. Discuss the intent of the activity, which is to learn to calculate the electrical usage of appliances. Explain how the number of watts of electricity used by an appliance can be calculated. Use the Units of Electricity sheet for this.

3. Explain how to convert watts to kilowatts and then how to calculate the number of kilowatt hours an appliance used during a given time.
4. Hand out the Appliances use energy sheet and do the sample calculation with the class. Go step by step allowing each student to complete that step before going on.
5. Assign each student to go home and find the information necessary to calculate the energy use for one or more appliances. They can use the worksheet to record their data (amps and volts) and do their calculations. After students have completed columns 1 through 7 of the worksheet, introduce the idea that electricity is paid for by the kilowatt hour. Tell students the cost per kilowatt hour of electricity in your area. Have them write it in column 8.
6. If you have computers, have a student program the calculations, using the Appliances/Energy/Money program. Let students see how quickly the computer will complete their work for them. Otherwise, carry out the calculations on paper or with a calculator.

Materials

2. Units of Electricity sheet
4. Appliances Use Energy sheet
5. take-home letter
6. (optional) Appliances/Energy/Money computer program, Commodore 64 computer

Estimated Time for Activity

1.5 hours over two days (plus time at home to collect data)

Typical Results

Many students will need a great deal of guidance doing this activity. Their results can be accurate if they do the arithmetic correctly. Close attention to decimal places is necessary.

Safety Notes

None

More Ideas

Write to the electric utility company for information on:

- the energy demands of various appliances
- how to read an electric meter
- how to save energy by using appliances efficiently.

Learn about different electric rate structures. Find out if your electric utility company has different rates for different kinds of customers, times of day, etc., and if so, why?

Select a room in your home and calculate the energy use for that room for one year. Calculate the cost of running that room for the year.



Units of Electricity

How can you figure out how much energy an appliance uses? The electric company charges you by kilowatt hours, in other words

- kilowatts of electric power you use, and
- number of hours you use them.

But how does that help? Many appliances are only marked with numbers of volts and amps. How can you figure out kilowatt hours from that? Here's how.

Sample calculation

Our example will be a refrigerator that runs on 110 volts, 5 amps. It runs for a quarter of an hour, every hour of the day and night. (That means 6 hours per day, total.)

Step 1 First find the number of watts, by multiplying the number of volts by the number of amps.

$$\begin{aligned}\text{number of watts} &= 110 \text{ V} \times 5 \text{ amps} \\ \text{number of watts} &= 550 \text{ watts}\end{aligned}$$

Step 2 Now change the number of watts to kilowatts. There are 1000 watts in a kilowatt. Divide the number of watts by 1000.

$$\begin{aligned}\text{number of kilowatts} &= 550 \text{ watts} / 1000 \\ \text{number of kilowatts} &= .55 \text{ kilowatts}\end{aligned}$$

Step 3 Finally, you want to calculate the number of kilowatt hours used by the refrigerator. Multiply the number of kilowatts by the number of hours the refrigerator is run per day.

$$\begin{aligned}\text{number of kilowatt hours} &= .55 \text{ kilowatts} \times 6 \text{ hours} \\ \text{number of kilowatt hours} &= 3.30 \text{ kilowatt hours}\end{aligned}$$

Now How much will this cost you? Every electric company has its own price for electricity. It may be as low as \$.05 per kilowatt hour, or as high as \$.25 per kilowatt hour.

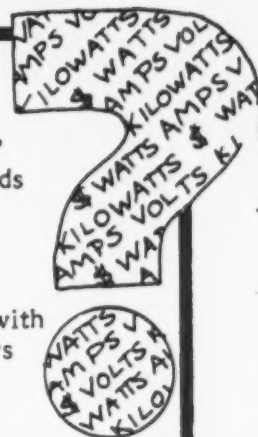
Let's pretend that your electric company charges \$.10 per kilowatt hour.

Step 4

$$\text{cost per day} = \text{number of kilowatt hours} \times \text{cost per kilowatt hour}$$

$$\begin{aligned}\text{cost per day} &= 3.30 \text{ kilowatt hours} \times \$.10 \\ \text{cost per day} &= \$.33\end{aligned}$$

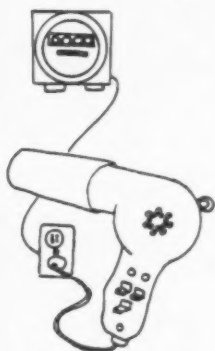
At last! You now know that it costs 33 cents a day to run the refrigerator.



Appliances use energy. Energy costs money.

You are going to figure out how much an appliance costs you per day. Here's how.

A. Fill in the ● columns (1,2,3,6, and 8)



Choose an appliance from your home. Write the name in column 1.

Copy the amps and volts marked on the back of the appliance, (columns 2 and 3).

Decide how many hours the appliance runs on an average day, (column 6).

Find out the cost of a kilowatt hour in your area, (column 8).

B. Figure out the answers for the □ columns (4,5,7,9).

by using the computer program Appliances/Energy/Money

or

by using a calculator

or

by using your brain and a paper and pencil!

●	●	●	□	□	●	□	●	□
1	2	3	4	5	6	7	8	9
appliance	amps	x volts	= $\frac{\text{watts}}{1000}$	= kilowatts	x average hours per day	= average kilowatt hours per day	cost per x kilowatt hour in your area	cost per appliance per day
Example: electric motor	10	110	$\frac{1100}{1000}$	1.1	5	5.5	\$.10	\$.55
			$\frac{\quad}{1000}$				\$. ____	\$. ____
			$\frac{\quad}{1000}$				\$. ____	\$. ____
			$\frac{\quad}{1000}$				\$. ____	\$. ____

To _____ Folks,

The electric bill is an important part of our energy budget.
This week the class is learning how to figure out HOW MUCH
ENERGY AN APPLIANCE USES AND HOW MUCH IT COSTS.

To practice doing this, your child needs to find out the required
volts and amps for three or four household appliances. This informa-
tion is usually recorded somewhere on the appliance. Will you help?

Thank you very much.

12. Question: Can recycling paper save energy?

Purpose

To give students first-hand experience in recycling.

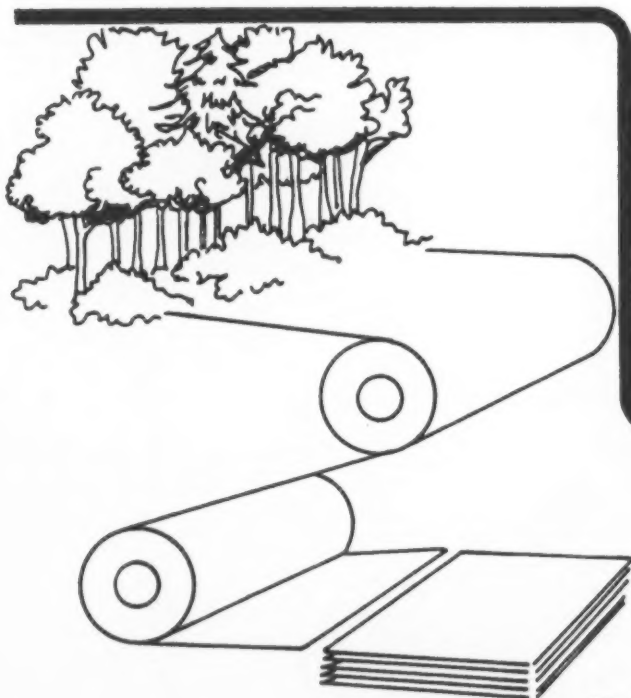
Introduction

Students discuss where paper comes from, and then collect discarded paper and make new paper from it. They then compare the energy consumption of recycling vs. that of using new raw materials.

Background

Paper is a commodity that is used and discarded by people every day; however, the energy resources necessary to produce paper products often go unnoticed.

Tree seedlings must be planted, nourished, and later harvested in forests for their pulp. This material must next be transported to the mill where energy is used in the paper manufacturing process.



12-1

Understandings

Material and energy can be transferred several times within a complex system through a series of interactions.

Skills

Recording data
Measuring
Manipulating materials
Acquiring information

Attitudes

Respecting others and the environment.

Enjoying working with materials.

Valuing the benefits of technology for the environment.

Finally, the finished products must be packaged and distributed to local markets where they are sold to the consumer. Energy is necessary at every step of this process.

The number of acres of forest reserves used for paper production could be decreased by reducing the amount of paper discarded and/or by recycling discarded paper products. In addition, recycling conserves energy resources by eliminating some of the steps involved in the production process.

Procedure

1. In a pre-activity discussion (at least a week in advance), ask the students how paper is used in school and at home, where paper comes from, and how it is made. Have them estimate how much

paper they throw out in school in a week.

2. Distribute worksheets, garbage bags, and marking pens and go over steps 1-4 from the How is paper recycled? sheet. Students need to save their scrap and waste paper for at least a week.
3. Assemble the necessary materials and prepare the starch solution one day in advance. Use one of the following formulas:
 - a. Two cups of cornstarch to four cups of water, or
 - b. Six tablespoons of laundry starch to six cups of water.

Mix with a blender and then, using a funnel, pour into plastic bottles.

One batch will make enough for 6 to 10 students.

4. Have students complete steps 5 and 6 from the worksheet. Use the chalkboard to list students and add up the weight of paper they collected.
5. Part 2, the actual paper-making, may be done by each student, groups of students, or as a class depending upon the availability of materials.
6. After the activity, talk about why we would want to recycle paper.

Ask: If we recycle paper, what do we save? Besides trees, do we save energy? What energy is used to grow, cut, and transport trees, and make them into paper? What steps do we eliminate by recycling?

Ask: Are there other kinds of recycling that do the same thing (aluminum cans, motor oil)? Can waste be used for fuel? Does this save energy? What kind of energy must we use more of when we recycle?

Materials

2. How is paper recycled? and Paper Saver sheets, light colored garbage bags, indelible markers, stapler
3. cornstarch or laundry starch, water, blender, funnel, plastic bottles, measuring cup
4. balance or postage scale
5. starch solution; waste paper; water; large empty margarine containers or plastic basins; eggbeaters, mixers, or a blender (works best); wire screen in 25 cm x 35 cm pieces; pipes, dowels, or rolling pins; cups; pails; index cards; old newspaper.

Estimated Time for Activity

0.5 hours for introduction

0.5 hours for weighing

1 hour for paper making and discussion

Typical Results

If a blender is used, the paper the students make will be fairly smooth textured, although it will be somewhat fragile. Without the blender, the paper may be more like cardboard.

Safety Notes

2. Warn students to keep the permanent markers away from their eyes and clothes.

Any paper products that held food or might harbor germs (napkins, tissues) should not be collected.

Store the plastic bags so that they do not inconvenience custodians.
5. Supervise students in the use of beaters and mixers. Electric mixers or blenders should be operated by the teacher only.

Students should wear safety goggles when they are working with the starch solution.

Some students may be allergic to the starch solution; have them wear plastic disposable gloves when touching the starch solution or pulp.

5. When rolling out the pulp mixture, direct the students to use light pressure so that the material does not stick to the rolling pin. Also make sure there is plenty of old newspaper beneath the screen to absorb the excess water pressed out.

More Ideas

Use the recycled paper for something special - a letter, invitation, decoration, certificate, etc.

Write to major paper manufacturers (or other industries) to find out what recycling and other energy conservation they are doing.

Write a play about saving the environment and saving energy.

Make papier mache' masks for use in the play.

Write to the National Forest Service, Cooperative Extension, or the Department of Environmental Conservation for information about good forest management.

Find out where there are paper recycling businesses in your area and what they pay for different kinds of paper.

How is paper recycled?

People say that we live in an "Information Society." And how do we get all that information? -- from TV and radio of course, but a lot of it comes to us on paper.

Just think of all the paper we use: newspapers, magazines, books, leaflets, envelopes, bags, packages, folders, boxes, wrapping paper, facial tissue, bathroom tissue, paper towels and wipes, record jackets, stickers, labels, notebooks.....

Where does it all come from? And where does it go?

Materials

paper used during school, a balance scale, white plastic garbage bags, a clean plastic basin, marking pen, an index card, a measuring cup, an eggbeater or blender, starch solution, clean water, newspaper, rolling pin, and a piece of wire screen (30 mesh about 25 cm x 35 cm)

Steps

Part 1: Preparations

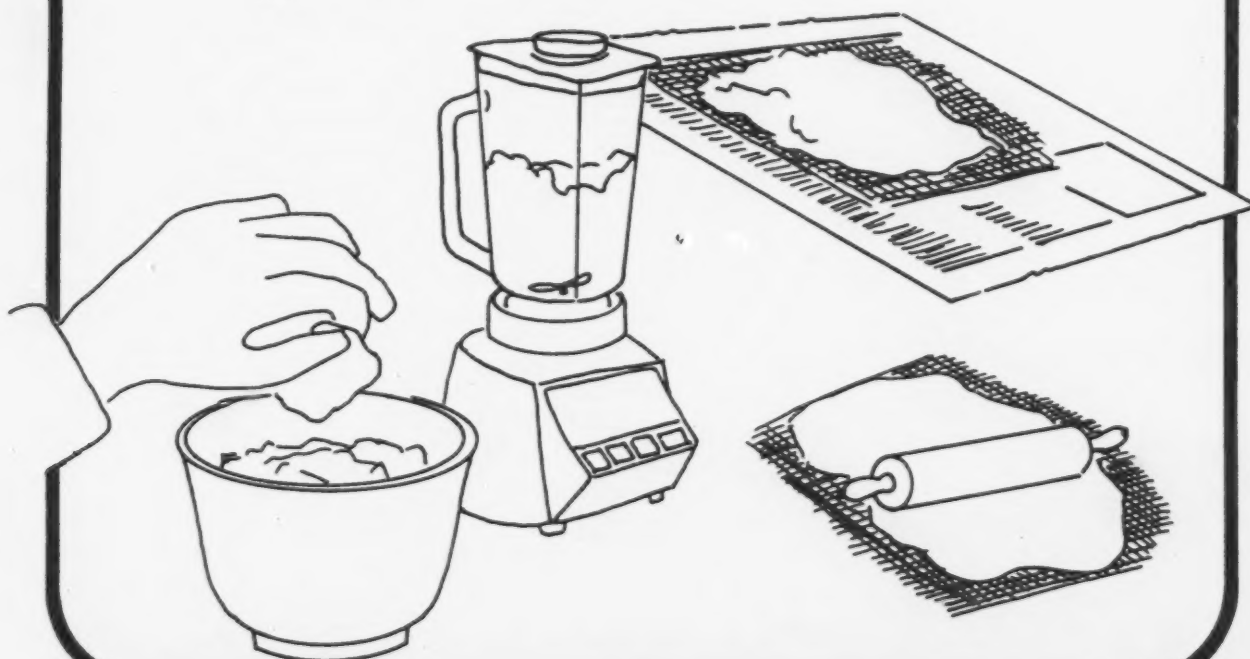
1. On a plastic garbage bag, write with a permanent marker your name and the date the activity is started.
2. Staple this sheet and your Paper Saver sheet to the bag so that you have them handy.
3. Instead of throwing any paper product in the waste basket, place it in your own personal plastic garbage bag. Continue for several days. Save all your waste paper except paper that has food or germs on it, like napkins or tissues. The only materials that you should throw away during this week are non-paper waste materials.
4. On the Paper Saver sheet keep a tally of all the sheets of paper you use during the days you are collecting. Include, in this tally, each paper that you turn in to your teacher, each paper that you take home, and each paper that you would have thrown out.



5. At the end of the collecting days, weigh the amount of paper in your plastic bag. Record this weight in the data sheet.
6. Make a list of all of the students in your class and the weight of paper each would have discarded; then add the numbers to find the total weight of paper your class would have thrown away in a week.

Part 2: Making Paper

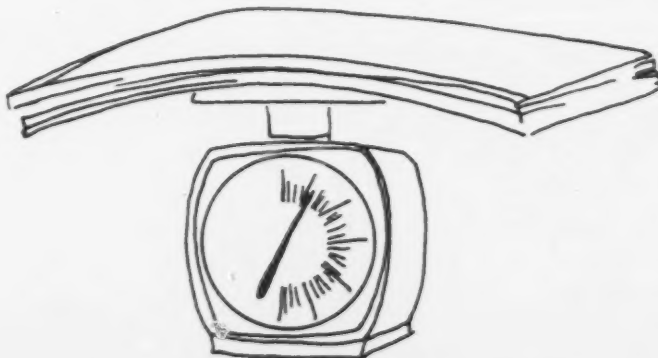
7. Tear sheets of paper from your plastic bag into small pieces about the size of a half-dollar and place them in the plastic basin. Add water and let the paper soak for 5 minutes. Pour off the water into one of the plastic pails provided by the teacher.
8. Get a cup of starch solution from your teacher and add it slowly to the wet torn paper. As you do this, beat the mixture of wet torn paper and starch solution with an eggbeater until it is the consistency of a thick soup or gravy. (If a blender is available, pour the starch solution and the wet torn paper into it and blend it at high speed.)
9. Spread newspaper on your desk, place a piece of the wire screen on top of the newspaper, and quickly pour the pulp mixture on top of the wire screen. Spread it evenly over the screen using the index card.
10. Remove the excess water by rolling the rolling pin lightly over the mixture while it is on the screen. Then peel off the wet "recycled paper" and dry it overnight. Trim it to size the next day.



Paper Saver

Date	Papers I have handed in to my teacher	Papers I took home	Papers saved that I would have thrown out
	Total papers handed in _____	Total papers taken home _____	Total papers saved _____

Total weight of the paper I saved _____



13. Question: What is pH and why is it important?

Purpose

To have students learn about acids, bases, and pH, and relate this knowledge to the problem of acid deposition.

Introduction

Students will test various substances to see whether they are acidic or basic, using litmus paper or pH paper. They will then relate this experience to acid deposition and hazardous or toxic substances through reading.

Background

The acid or basic nature of a liquid is important in determining the use for the liquid.

Our stomach liquids are acidic so that specific enzymes can help in digestion. Bathroom toilet bowl cleaners are strongly acidic or basic so that they can effectively clean. Automobile battery fluids are acidic so that electrical energy can be produced.



Understandings

Material may be transferred from one location to another in a complex system.

Energy entering the ecosystem interacts with and changes the physical environment.

Skills

Manipulating materials
Observing
Recording and interpreting data
Classifying
Acquiring information through active reading and listening

Attitudes

Valuing careful, systematic investigation

Respecting others and the environment.

Having concern for potential consequences of technology on the environment.

The above examples are all positive uses for acidity and/or basicity. Sometimes there is too much of one or the other and problems arise. For example, if our stomachs are too acid we get a stomach ache. It is important for children to understand the idea that liquid substances may have these characteristics and that certain effects may result.

Whether a liquid is acidic, basic, or neutral is measured by a quantity called pH. pH is a measure of how much hydrogen, in an ionic form, is in a solution. pH measurements are put on a scale from 1-14, with 1 being the most acidic and 14 the most basic. If a solution has a pH of 7 it is said to be neutral.

The pH scale is a "power of 10" scale. In other words, something with a pH of 9 is ten times as basic as something a pH of 8.

There are several techniques used to measure pH. Litmus paper or pH paper are commonly used when the measurements do not need to be highly accurate. pH meters are used when accurate measurements are needed.

In this activity, litmus paper will be used since it is easily obtained and used. Blue litmus paper turns red in an acidic solution and red litmus paper turns blue in a basic solution.

The issue of acid deposition is one that has energy, environmental, and scientific ramifications. (One step in determining if a body of water has been affected by acid deposition is to measure its pH accurately over time and under various conditions.) There is much to learn about the relevant conditions, and research is continuing. Since the major contributor to acid deposition today is the burning of fossil fuels in cars, factories, and power plants, children should understand that acid deposition is an energy issue.

Once they understand pH, students can be introduced to the idea that many familiar and innocent-looking substances may in fact be hazardous or toxic substances. They can learn to beware of the possible effects of these substances on health and the environment.

Children should be aware of the fact that all energy sources and many of the other conveniences of modern life have environmental consequences. Acid deposition is one which needs a great deal of study so that prompt and appropriate action can be taken.

Procedure

1. Prior to the lesson, collect substances from home to be tested. They should be liquids or substances that will dissolve in water. Such things as bi-carbonate of soda, vinegar, lemon juice, orange juice, very dilute ammonia cleaner, dilute bleach, dilute oven cleaner, tap water, or dilute acids or bases from the junior or senior high school chemistry lab all will work well.
2. Have the students prepare a class data table on the board, such as the one below, on which to record their results.

If you plan to use pH paper instead of litmus paper, you will need to change the instructions and the data table on the Acid Test Data Sheet.

3. Group the students into teams, and assign to each team several substances to test. Have a team recorder enter the group's results on the board.
4. For each substance to be tested, list its name, if known, and the reaction of a piece of red litmus and a piece of blue litmus. Have each substance tested with both color papers. Remind students not to drop papers into the glass containers.
5. After substances have been tested, students should make their own record of how each substance reacted on the Acid Test Data sheet. This is a type of classification. Have the students classify the substances as acid, base, or neutral.
6. Discuss the students' classifications. If differences are noted, point out that classification is based on data collected and that changes cannot be made without further testing.

7. Using the information on pH on the data sheet, relate the idea of acidity to the pH scale. Use as an example of the importance of pH the idea that certain animals live in ponds and lakes that are above a certain pH. If the pH is lowered too much, the animals die. One way that a body of water's pH can be lowered is by acid deposition. Read What is pH? and Why worry about acid rain? and discuss.
8. Go over the Substance Safety sheets, and discuss.
9. After the discussion, have the students write a statement which describes pH and its importance to living things. Have them include the connection to acid deposition.

Materials

1. various liquids or soluble solids
2. Acid Test Data sheets, chalkboard
4. clean glass cups or jars, various liquids, litmus paper (red and blue) or pH paper, Acid Test Data sheets
7. What is pH? sheet
8. Substance Safety sheet

Estimated Time for Activity

1 hour to test and record data

1 hour (perhaps over two days) to read and discuss readings

Typical Results

Litmus paper will react with liquids quite readily as will pH paper. The concentrations of the solutions will determine, to some extent, the reaction gotten.

Safety Notes

Ammonia, bleach, and other strong cleaners should be diluted about 10 to 1 for this activity.

Students should wear goggles.

Be prepared for spills.

Instruct students in the safe way to handle unknown substances. This should include:

- a. never tasting them,
- b. being careful in smelling them,
- c. if spilled on skin, washing skin thoroughly with large amounts of water.

Students should have been taught classification skills prior to doing this activity.

More Ideas

Dilute an acid to lower and lower concentrations and test with blue litmus. See how low you must go before the litmus fails to react.

Find information concerning acid deposition, commonly called acid rain. List several problems related to acid deposition.

Try testing collected rainfall or melted snow, to see if it is acidic enough to affect litmus paper.

Obtain some pH paper. Measure the pH of several bodies of water in your area.

Acid Test Data Sheet

Pure, distilled water is neutral. Most other liquids are either acid, or base. How can you tell?

Litmus paper allows you to make a simple test.

Blue litmus paper turns red in acids.

Red litmus paper turns blue in bases.

Try it!

Materials

several clean glass containers

blue and red litmus paper

several liquids to test



Steps

1. Place a small amount of one liquid to be tested in a clean glass container.
2. Take a strip of red litmus paper and dip one end in the liquid and record the result in your data table.
3. Repeat using a strip of blue litmus paper and record your results.
4. Repeat steps 1,2, and 3 for all of the liquids your teacher gives you to test. Remember, the glass container must be clean.
5. You have tested the substances. Now classify the substances according to the characteristics acid, base, or neutral.
6. Copy the information from your Data Table onto the chalkboard so other students can record your data.
7. From the blackboard, copy information about other substances tested by other students.

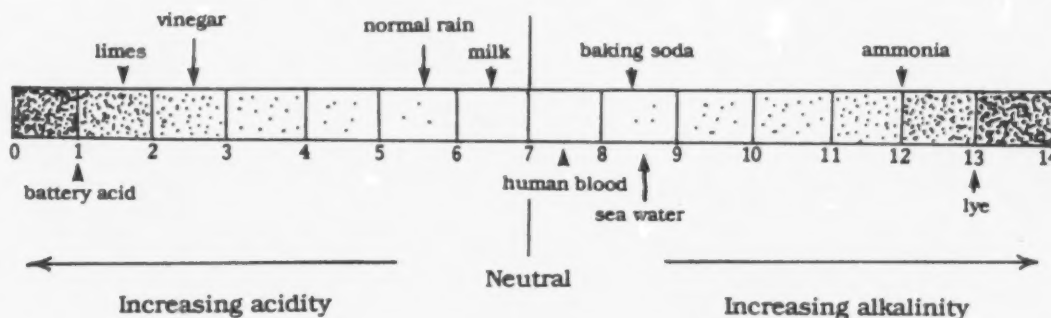
Substance	Red litmus test results	Blue litmus test results	Classification (acid, neutral, or base?)

Data Table

What is pH?

The symbol pH stands for a way of classifying substances. The pH scale is a 14-point scale. The middle number, 7, means neutral. The low end is acids; the high end is bases. A liquid with a very low number is very acidic. One with a very high number is very basic.

Here are some examples.



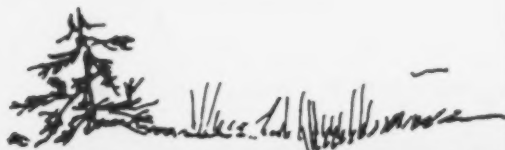
Why worry about acid rain?

You have probably heard things in the news about acid rain. In fact, normal rain is somewhat acidic. And actually, water that is quite acid may not be at all dangerous for humans. After all, we can drink lemon juice, which has a pH of less than 3.

But for plants, and for animals that live in water, a low pH can be bad. If a lake's pH gets below 5, many fish will die. What causes this so-called acid rain?

When coal or oil are burned, they release substances into the air. Some of those substances are acid. They may settle out of the air, or mix with moisture in the air. Then the rain or snow becomes more acidic.

Sooner or later, the acidic substances get back to ground level. They fall on forests, fields, and lakes. Not all fall as rain, though. It is really more accurate to say "acid deposition," not acid rain.



The causes and effects of acid deposition are not completely understood. We do know that exhaust from cars, trucks, and buses is the main source of nitrogen oxides (NO_x). Factories, including smelters and electric generating plants are the main source of sulfur dioxide (SO_2).

We certainly don't want to give up driving cars or using electricity. But we don't want to damage our environment either. That is why today a lot of research is going on to pinpoint the causes and effects of acid deposition.

You have just learned about pH.

When scientists study acid deposition, they are actually keeping an eye on the pH of our environment.



Substance Safety in the Home

We think of home as a safe place, and it usually is. However, in modern homes and apartments we use lots of things that aren't so safe, especially for small children.

Some of these things are very acidic or very basic. Others contain chemicals that are poison.

cleaning products

polish

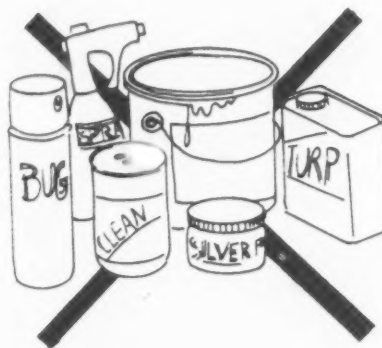
motor oil and gasoline

paints and stains

insect spray

cosmetics and perfumes

medicines and creams



You are old enough to understand these things and learn to use them safely. Most important, you can help to protect younger children from toxic substances in the home.

Never taste or smell something marked:

DANGEROUS

TOXIC

POISON

ACID or

WARNING

If there are young children around, these toxic substances should be kept where they cannot be reached, opened, or spilled.

Never mix unfamiliar substances. Even common cleaners can be dangerous if mixed.

Wear rubber gloves to handle or use toxic substances. If some gets on your skin, wash it thoroughly.

Keep toxic substances away from flames or heat. The substances are often flammable, and spray containers may even explode.

Most hospitals have a "poison unit." Keep the phone number handy in case someone accidentally swallows something toxic.

To _____ Folks,

This week the class has been learning HOW YOU CAN TELL IF SOMETHING IS ACIDIC, by testing various substances. The class has also talked about how some substances can be dangerous because they are very strong acids or bases, or contain toxic chemicals. They learned about pH, a way of measuring acidity, and found that water that is acidic can be bad for plants and fish.

You may wish to discuss acid deposition with your child, as well as other environmental issues that are connected to our use of energy.

Glossary

a

acid: a sour tasting substance that can break down other materials, and that turns blue litmus paper red. Most acid found in rain and snow is caused by burning fossil fuels.

acid deposition: the depositing of acid in the environment in snow, hail, sleet, fog, dew, frost, or dry sediment. The acid is the result of air pollution.

air: the mixture of gases that surrounds the earth. Air is odorless, tasteless, and colorless. It contains oxygen and carbon dioxide, which are used by living things.

alcohol fuel: fuel made by distilling grain, wood, or other plant products into alcohol.

alkaline battery: a dry cell battery that uses a highly alkaline (basic) electrolyte and gives a high charge for a relatively long period of time.

ampere: the unit of measurement of the rate of flow of an electric current (number of electrons/second).

appliances: machines, especially household machines, that use energy (usually electricity) to do work.

armature: a part of an electric motor or generator that revolves between the poles of a magnet (or within which a magnet revolves). It is made of wire wound around an iron core.

b

base: a substance that feels soapy when mixed with water, and that turns red litmus paper blue (also called alkali).

battery: a container holding wet or dry electrolytes that produce electricity.

biomass: an amount or volume of plant material in any form: algae, wood, crop residue, animal manure, etc. Biomass contains energy stored in chemical form.

c

caulking: a soft material that can be squeezed into the cracks of a building, to reduce the flow of air into and out of the building.

chemical energy: the energy released when substances combine or break down and form new substances.

chemical reaction: the combining or breaking down of substances to form new substances. Energy is used or given off in the reaction.

circuit: an arrangement of wires, tubes, etc., through which electricity flows.

clouds: masses of tiny drops of water or ice particles floating in the air high above the earth.

coal: a fossil fuel; a black rock composed mostly of carbon, formed under the earth's surface over millions of years from the remains of plants. Used as a fuel because it burns easily, coal causes air pollution when burned. It is a non-renewable energy source due to the conditions and time necessary to form it.

cold: having little heat energy.

conduction: the process by which heat or electrical energy travels through substances.

convection: the process by which heat energy travels in currents of air, water, or other fluids.

current: flow of electricity through a wire. The rate of flow is measured in amperes.

d

dam: a wall built to hold back flowing water. A dam may be part of a hydropowered generating plant.

decay: to rot or become rotten; to break down.

decomposition: rotting and breaking down of substances into what they are made of.

distance: the space between objects, or the space an object travels in a certain length of time.

distribution lines: heavy-duty wires that are used to distribute electricity from substations to nearby energy customers.

dry cell battery: a battery with the electrolyte in a paste form to reduce the risk of leaks.

e

electric current: a flow of electricity through a wire that can be measured, and is used to operate appliances, lights, etc.

electrical system (car): the system of devices and wires that produces and distributes electrical energy in a motor vehicle. Includes an electrical generator and a storage battery.

electricity: a form of energy that can produce light, heat, motion, and magnetic force. Electricity is a flow of electrons that can be produced by generators, friction, or chemical change in a battery.

electrolyte: a chemical (compound) which when dissolved in water will conduct an electrical current.

energy: the ability to do work. Light, heat, electricity, and gravity are some forms of energy.

engine (car): a machine that burns fuel to convert its chemical energy into mechanical energy.

exhaust system (car): a series of connected pipes that helps remove the waste products of an automobile engine.

f

force: any push or pull on an object.

fossil fuels: non-renewable energy sources (coal, petroleum, and natural gas) that must be mined or pumped from the ground and then burned to release their energy. A large share of our energy comes from fossil fuels; however, mining and burning them cause pollution and damage the earth's surface. These fuels are formed from the fossilized remains of plants and animals that have been buried for millions of years.

friction: a rubbing of one thing against another. The force that results when two moving objects are in contact with each other.

fuel: something that can be burned or broken down to produce heat energy.

fuse box: a small metal box connected to the main electrical circuit in a building. It contains fuses which are small metal strips inserted into an electrical circuit that melt and break the connection when the current becomes too strong.

g

gas turbine: a turbine that produces electricity by using the force of hot, expanding gases to make it revolve. The gases are produced by burning a fuel.

generator: a machine that changes energy of motion (mechanical) into electrical energy. It consists of a magnet and a coil of wire.

geothermal energy: the heat energy in the rocks, hot water, and steam in the earth's crust.

h

head (water power): the height that water from behind a dam falls to reach the turbine.

heat: the energy given off when the molecules of a substance move.

home: a place where a person or family lives. A home may be an apartment, a house, a mobile home, etc.

hot: having much heat energy.

hydropowered generating plant: a building or dam that contains machines that use the energy from falling water to make electricity.

i

ice: water made solid by cold; frozen water.

insulation: a material that slows heat loss or waste. Fiberglass, cellulose, rockwool, and styrofoam are examples.

j

joule: a metric unit of energy, equal to the energy used in one second by an electric current of one ampere, with a resistance of one ohm.

k

kilowatt: a measure of electric power, equal to 1000 watts, or to energy consumption at a rate of 1000 joules per second.

kilowatt hour: amount of energy equal to one kilowatt of power being used for one hour.

l

light: a form of energy that animals use to see and that plants use to make food. When light is absorbed by objects they heat up.

m

magnet: a piece of metal that has the ability to attract iron or steel with magnetic force.

mass: the amount of matter in a substance.

mechanical energy: energy due to the motion of an object. For example: the energy of the moving parts of an automobile engine.

meter: a device that measures the amount of natural gas, water, or electricity that is being used.

methane: a colorless gas that burns easily. It forms from the decomposition of once living materials, or can be made from petroleum. Natural gas contains methane.

motion: moving, or movement from one place to another.

N

natural gas: a fossil fuel; a colorless gas containing methane that formed over millions of years from the remains of plants and animals. It must be pumped from the earth, and is used as a heat fuel because it burns easily and cleanly. Natural gas is a non-renewable energy source due to the conditions necessary to form it.

neutral: neither acid or basic, does not react.

nickel-cadmium rechargeable battery: a dry cell battery with an alkaline (basic) electrolyte; a type of storage battery.

non-renewable energy sources: sources of energy that are in limited supply, and take millions of years to replace. For example: oil, coal, natural gas, uranium.

nuclear fuel: an energy source made from materials that must be mined from the ground and processed to obtain the radioactive elements. It is used as fuel in a nuclear reactor to produce electricity. Some nuclear fuels can be made by reprocessing other nuclear fuel after it is used.

O

oil: a fossil fuel; a thick, black liquid that is lighter than water, burns easily, and was formed over millions of years from the remains of plants and animals. It must be pumped from the earth and separated into products such as gasoline, kerosene, lubricants, plastics, etc. Oil causes air pollution when burned, and is a non-renewable energy source due to the conditions and time necessary to form it.

outlets: small openings in a wall where electrical plugs can be inserted to connect with wires that carry electricity.

P

penstock: a large pipe that carries water to a turbine in a hydroelectric plant.

pH: a measure of how acidic or basic a substance is. The pH scale goes from 0 to 14 with 7 being neutral, below 7 increasingly acidic, and above 7 increasingly basic.

pH paper: white paper saturated with litmus, used to indicate the pH of substances by changing color.

photosynthesis: the process by which green plants use sunlight to make food.

pipeline: a line of connected pipes used for carrying liquids or natural gas.

plants: any living things that are not animals. Plants are unable to move by themselves and lack a nervous system and sense organs. Green plants manufacture their own food.

q,r

rain: water falling to earth in drops from clouds.

recycle: to recover something so that it may be used again.

renewable energy sources: sources of energy that can be replenished in a short time, that are never really used up. For example: energy from the sun, wind, falling water, growing plants.

reservoir: a place where water is collected and stored for future use.

S

save: to keep from being used up or wasted.

snow: water vapor frozen into crystals that fall to earth in soft, white flakes.

soil: tiny particles of inorganic (rocks, minerals) and organic (decayed plants, animals) materials necessary for support and nourishment of plants.

sound: energy in the form of vibrations that travel through air, solids, and liquids, and produce "sounds" in the ear.

soundwaves: sound energy that travels through the air as a wave, at 1087 feet or 331 meters per second.

steam: the vapor that is given off when water is heated to the boiling point. Steam is a source of heat energy.

steam powered generating plant: a building that contains machines that make heat or electricity from steam. The steam is produced by burning coal, oil, natural gas, or garbage, or by using nuclear fuel, to boil water.

steam turbine: a turbine that produces electricity by using the force of steam to make it revolve.

storage battery: a battery that may be recharged after use.

substation: a building that has machines that help divide and regulate the flow of electricity from place to place.

sun: the star around which the earth and other planets revolve. The sun supplies the planets with light and heat.

sunlight: the light energy given off by the sun, which can be collected and used as a source of heat.

sun's energy: made up mostly of heat and light produced by the sun; known as solar energy. It can be collected and used to heat buildings and water, to produce electrical energy, and for lighting.

sustained: kept going.

t

temperature: a measure of heat or cold; a measure of the amount of energy in something.

thermometer: an instrument that measures heat energy.

thermostat: a device for sensing temperature; used to turn heating and cooling machines on and off at certain temperatures.

toxic substances: substances that are harmful to living things. These substances may also be useful products or byproducts of industry, energy production, etc.

transmission (car): the part of a motor vehicle that sends power from the engine to the axle(s) that turn the wheels.

transmission lines: heavy-duty wires that are used to carry electricity from one place to another, for example, from a generating plant to substations.

turbine: a device consisting of a wheel with blades that uses the force of water, wind, steam, or other hot gases to revolve it. A turbine is used to turn a generator to produce electricity.

u

utility company: a company that provides energy for people to use; sometimes owned by the public and sometimes by stockholders.

v

vapor: water in the air in the form of a gas.

vibrate: to move back and forth rapidly.

voicebox: the part of the throat that vibrates and produces the sounds of speech.

volt: the unit of measurement of the force needed to move electricity through a wire.

w

waste: to make poor use of, to use up without thought.

water: the most common liquid on earth, that falls from the sky as rain and forms rivers, oceans, etc. Pure water is colorless, tasteless, and odorless. Made up of hydrogen and oxygen.

water cycle: the process in which the sun evaporates water from the earth's surface, and the water is returned to the earth's surface in the form of precipitation from the atmosphere.

water power: energy (usually electricity) that is made from falling or running water.

water turbine: a turbine that uses the force of falling water to produce electricity.

water vapor: water in the form of a vapor.

watt: a unit of measurement of the amount of work done by an electric current per second (power).

weatherstripping: a material that is applied around doors and windows to reduce the flow of air.

wet cell battery: a battery with a liquid electrolyte.

wind: air in motion, caused by differences in the temperature and pressure of air masses.

windmill: a machine powered by the force of the wind on a wheel with vanes or sails, mounted on a tower; used to pump water, grind grain, generate electricity, etc.

wind-powered electric generator: an electric generator that is powered by a windmill or wind turbine.

wind turbine: a turbine that uses the force of the wind to produce electricity.

wood: a hard substance found beneath the bark of trees and shrubs. Wood is used as a fuel because it burns easily. It causes air pollution when burned. Wood is a renewable energy source because trees and shrubs can be replenished in a few years.

work: the use of the force of energy to move something a certain distance.

X,y,z

zinc-carbon battery: a standard dry-cell battery, which uses an acid for the electrolyte. It is not rechargeable.

Resources

Level I

- I, 1. Everything Moves, by Seymour Simon
 (New York: Walker and Company, 1976)
- Popcorn Dragon, by Jane Thayer
 (New York: William Morrow & Co., Inc., 1953)
- Sometimes Things Change, by Patricia Eastman
 (Chicago: Children's Press, 1983)
- I, 2. Gravity All Around, by Tillie S. Pine and Joseph Levine
 (New York: McGraw Hill Book Company, Inc., 1963)
- Please, Wind?, by Carol Greene
 (Chicago: Children's Press, 1982)
- I, 3. The Cloud Book, by Tomie de Paola
 (New York: Holiday House, 1975)
- The Day We Saw the Sun Come Up, by Alice E. Goudey
 (New York: Charles Scribner's Sons, 1961)

Rain and Hail, by Franklyn M. Branley
(New York: Thomas Y. Crowell Company, 1963)

Science Experiences: Solids, Liquids, and Gases, by Jeanne Bendick
(New York: Franklin Watts, Inc., 1984)

I, 4. Rusty Rings a Bell, by Franklyn M. Branley
(New York: Thomas Y. Crowell Company)

I, 5. Energy from the Sun, by Melvin Berger
(New York: Thomas Y. Crowell Company, 1976)

Roots Are Food Finders, by Franklyn Branley
(New York: Thomas Y. Crowell Company, 1975)

I, 6. Energy, Food, and You, (elementary booklet)
(Washington State Office of Environmental Education, c/o Shoreline School
District Administration Building, NE 158th and 20th Ave., NE, Seattle, WA
98155)

What Happens to a Hamburger, by Paul Showers
(New York: Thomas Y. Crowell, Company, 1970)

I, 7. Heat, by Vicki Cobb
(New York: Franklin Watts, Inc., 1973)

Hot and Cold, by Irving Adler
(New York: Harper & Row, John Day Junior Books, 1975)

I, 8. How We Move Things (filmstrip)
(Popular Science Publishing Company, 1962)

I, 9. Arthur's New Power, by Russell Hoban
(New York: Thomas Y. Crowell Company, 1978)

Blackout, by Anne and Harlow Rockwell
(New York: Macmillan Publishing Company, Inc., 1979)

Play It Safe -- Away from Electricity
(South Deerfield, MA: Channing L. Bete Co., Inc., 1977)

I, 10. Energy from the Sun, by Melvin Berger
(New York: Thomas Y. Crowell Company, 1976)

I, 11. More Power to You: An Energy Conservation Puppet Show
(The Peppermint Playhouse Puppeteers, 620 Red Oak Drive, River Vale, NJ
07675. Telephone: 201-666-2275)

- I, 12. The Berenstain Bears' Science Fair, by Stan and Jan Berenstain
(New York: Random House, Inc., 1977)

Energy Mobile (kit of cut-outs and teachers' guide)
(NYS Energy Office, Office of Communications, 2 Rockefeller Plaza, Albany,
NY 12223)

Level II

- II, 1. Wind, (10 minute color film)
(National Film Board of Canada, 1973)

Energy All Around Us, by Tillie S. Pine and Joseph Levine
(New York: McGraw-Hill Book Co., 1975)

Energy at Work, by John Satchwell
(New York: Lothrop, Lee and Shepard Books, 1981)

Energy Does Work, (13 min. color film)
(Barr Films, 1981)

Feast or Famine? The Energy Future, by Franklyn Branley
(New York: Thomas Y. Crowell Company, 1980)

Powers of Nature (filmstrip)
(Washington, D.C.: National Geographic Society, 1973)

Where Are You Going with That Energy?, by Roy Doty and Leonard Marr
(New York: Doubleday & Co., Inc., 1977)

- II, 2. Science Experiments with Sound, by Harry Sootin
(New York: W. W. Norton & Co., 1964)

Sound and Recording, by Keith Wicks
(New York: Franklin Watts, Inc., Warwick Press, 1982)

Thunder, Singing Sands, and Other Wonders: Sound in the Atmosphere, by Kenneth Heuer
(New York: Dodd, Mead, Co., 1981)

Wonders of Sound, by Rocco Ferauolo
(New York: Dodd, Mead & Co., 1962)

- II, 3. Dining on a Sunbeam: Food Chains and Food Webs, by Phyllis S. Busch
(New York: Four Winds Press, 1973)

How to Grow a Jelly Glass Farm, by Kathy Mandry and Joe Toto
(New York: Pantheon Books, 1974)

Making a Native Plant Terrarium, by D. J. Herda
(New York: Julian Messner, 1977)

- Putting the Sun to Work, by Jeanne Bendick
(Champaign, IL: Garrard Publishing Company, 1979)
- The Sun: Earth's Star (20 min. color film to rent)
(National Geographic Society, Educational Services, 1980)
- Terrariums, by Alice Parker
(New York: Franklin Watts, Inc., 1977)
- The True Book of Weather Experiments, by Illa Podendorf
(Chicago: Children's Press, 1961)
- Who Stole the Water (10 min. color film/video to rent)
(Macmillan Films, 1975)
- II, 4. Factory Made: How Things are Manufactured, by Leonard Gottlieb
(Boston, MA: Houghton Mifflin, Co., 1978)
- From Apple Seed to Applesauce, by Hannah Lyons Johnson
(New York: Lothrop, Lee, & Shepard Books, 1978)
- How's It Made?: A Photo Tour of Seven Small Factories, by Stephen Lewis
(New York: William Morrow & Co., 1977)
- How Things are Made
(Washington, D.C.: National Geographic Society, 1981)
- Your Career in Energy-Related Occupations, by George Davis.
(New York: Arco Publishing Co., 1980)
- Toast (12 minute film)
(NYS Energy Office, AV Library, 2 Rockefeller Plaza, Albany, NY 12223, 1977)
- II, 5. Experiments with Heat, by Harry Soutin
(New York: W. W. Norton & Co., 1964)
- Heat, by Vicki Cobb
(New York: Franklin Watts, Inc., 1973)
- Heat and Its Uses, by Irving and Ruth Adler
(New York: Harper & Row, John Day Junior Books, 1973)
- Hot and Cold, by Irving Adler
(New York: Harper & Row, John Day Junior Books, 1975)
- Hot as an Ice Cube, by Philip Balestrino
(New York: Thomas Y. Crowell Company, 1971)
- II, 6. Energy Conservation: Experiments You Can Do . . . from Edison
(Southfield, MI: Thomas Alva Edison Foundation, 1981)

- II, 7. Flash, Crash, Rumble, and Roll, by Franklyn M. Branley
(New York: Thomas Y. Crowell Company, 1964)
- The Lightning and Thunder Case (animated film or video to rent)
(Learning Corporation of America, 1981)
- II, 8. Making Electricity Work, by John M. Kennedy
(New York: Thomas Y. Crowell Company, 1959)
- Wires and Watts, by Irwin Math
(New York: Charles Scribner's Sons, 1981)
- II, 9. Experiments with Electric Currents, by Harry Sootin
(New York: W. W. Norton & Co., 1969)
- The Magic of Electricity, by Sam Rosenfeld
(New York: Lothrop, Lee & Shepard Books, 1963)
- II, 10. Saving Electricity, by Sam and Beryl Epstein
(Champaign, IL: Garrard Publishing Co., 1977)
- II, 11. Cup and Saucer Chemistry, by Nathan Shalit
(Morristown, NJ: Shalit Literary Service, 1983)
- First Chemistry Book for Boys and Girls, by Alfred Powell Morgan
(New York: Charles Scribner's Sons, 1977)
- Kitchen Chemistry: Science Experiments to Do at Home, by Robert Gardner
(New York: Julian Messner, 1982)
- Messing Around with Baking Chemistry: A Children's Museum Activity Book, by
Bernie Zubrowski
(Boston, MA: Little, Brown & Co., 1981)
- II, 13. Conservation of Energy, by Jane Werner Watson
(New York: Franklin Watts, Inc., 1978)
- Energy Monsters: How to Starve Them, (film 13 min, color to rent)
(BFA Educational Media, 1978)
- Future Sources, by John Satchwell
(New York: Franklin Watts Inc., 1981)
- Oil, by Barbara Lowery
(New York: Franklin Watts Inc., 1977)
- The Alternate Energy Suite (tape cassette and supplementary materials)
(Conservation Consultants, 417 Thorn St., Sewickley, PA 15143)

Level III

- III, 1. American Windmills, by Sharon Cosner
(New York: David McKay Co., 1977)
- Catch the Wind, by Landt Dennis
(New York: Four Winds Press, 1976)
- Motors and Engines and How They Work, by Harvey Weiss
(New York: Thomas Y. Crowell Company, 1969)
- III, 2. The Boys' Book of Engines, Motors and Turbines, by Alfred Morgan
(New York: Charles Scribner's Sons, 1946)
- Motors and Engines and How They Work, by Harvey Weiss
(New York: Thomas Y. Crowell Company, 1969)
- III, 3. Machines, by Jerome S. Meyer
(Cleveland: World Publishing Co., 1968)
- The Simple Facts of Simple Machines, by Elizabeth James and Carol Barkin
(New York: Lothrop, Lee & Shepard Co., 1975)
- Simple Machines and How We Use Them, by Tillie Pine and Joseph Levine
(New York: McGraw Hill Co., 1965)
- III, 4. Solar Energy, by Franklyn M. Branley
(New York: Thomas Y. Crowell and Company, 1957)
- Sun Power, by Steve J. Gadlert and Wendy W. Adamson
(Minneapolis: Lerner Publishing Co., 1978)
- III, 5. Experiments with Heat, by Harry Soutin
(New York: W. W. Norton & Co., 1964)
- Heat and Its Uses, by Irving and Ruth Adler
(New York: The John Day Co., 1973)
- Ice Cubes, Elementary Science Study
(St. Louis: McGraw-Hill Book Company, Inc., 1975)
- III, 6. Heat and Its Uses, by Irving and Ruth Adler
(New York: The John Day Co., 1973)
- Solar Energy, by Franklyn M. Branley
(New York: Thomas Y. Crowell and Company, 1957)

- Sunpower Experiments: Solar Energy Explained, by Maggie Spooner
(New York: Sterling Publishing Co., 1980)
- III, 7. The Boys' Book of Engines, Motors and Turbines, by Alfred Morgan
(New York: Charles Scribner's Sons, 1946)
- Motors and Engines and How They Work, by Harvey Weiss
(New York: Thomas Y. Crowell Company, 1969)
- Machines, by Jerome S. Meyer
(Cleveland: World Publishing Co., 1968)
- III, 8. The Boys' Book of Engines, Motors and Turbines, by Alfred Morgan
(New York: Charles Scribner's Sons, 1946)
- Batteries and Bulbs, Elementary Science Study
(St. Louis: McGraw-Hill Book Company, Inc., 1968)
- Magnetism, Electricity, Sound, by Rocco V. Ferauolo
(New Jersey: Prentice Hall, Inc., 1968)
- Picture Book of Electricity, by Jerome Meyer
(New York: Lothrop, Lee & Shepard, 1953)
- III, 9. The Boys' Book of Engines, Motors and Turbines, by Alfred Morgan
(New York: Charles Scribner's Sons, 1946)
- Energy & Environment, by Norman F. Smith
(Austin, TX: Steck-Vaughn, Co., 1974)
- III, 10. Electricity, by Leslie Waller
(New York: Holt, Rinehart & Winston)
- Junior Science Book of Electricity, by Rocco V. Ferauolo
(Champaign, IL: Garrard Press, 1960)
- Picture Book of Electricity, by Jerome Meyer
(New York: Lothrop, Lee & Shepard, 1953)
- Science at Work, by Seymour Simon
(New York: Franklin Watts, Inc., 1971)
- III, 11. Electricity
(Irving, TX: Boy Scouts of America, 1984)
- Energy, The New Look, by Margaret O. Hyde
(New York: McGraw-Hill Book Company, Inc., 1981)
- It Works Like This, by Thomas G. Aylesworth
(Garden City, NY: Doubleday & Co., 1968)

- III, 12. About Garbage and Stuff, by Ann Zane Shanks
(New York: The Viking Press, 1973)
- Recycling, by James and Lynn Hahn
(New York: Franklin Watts, Inc., 1973)
- Recycling Resources, by Laurence Pringle
(New York: Macmillan Publishers, 1974)
- III, 13. Chemistry, by Jane Chisholm and Mary Johnson
(London: Usborne Publishing Co., 1983)
- What Makes a Lemon Sour?, by Gail K. Haines
(New York: William Morrow & Co., 1977)

Matrix

The matrix on the following pages is taken from the draft edition of the New York State Education Department's elementary science syllabus.

The state syllabus divides learning objectives into three categories:

understandings,
skills, and
attitudes.

In Energy and Safety, the major state objectives addressed are listed on the first page of each activity, in a box, under the titles "Understandings," "Skills," and "Attitudes," as in the state syllabus. However, any given activity actually addresses many objectives. This matrix is designed to show all the objectives that are introduced, taught, or reinforced by each activity. Its purpose is to help teachers use the Energy and Safety activities in conjunction with the state syllabus.

Key:

- ☒ means the activity introduces this understanding, skill or attitude.
- ☐ means the activity teaches this understanding, skill or attitude.
- ☒ means the activity reinforces this understanding, skill, or attitude.

SYLLABUS - PROGRAM CORRELATION CHART
Level I, Grades K-2

		Activities											
		1	2	3	4	5	6	7	8	9	10	11	12
INQUIRY SKILLS	CLASSIFYING												
	CREATING MODELS												
	FORMULATING HYPOTHESES												
	GENERALIZING												
	IDENTIFYING VARIABLES												
	INFERRING												
	INTERPRETING DATA												
	MAKING DECISIONS												
	MANIPULATING MATERIALS												
	MEASURING												
	OBSERVING												
	PREDICTING												
	RECORDING DATA												
	REPLICATING												
	USING NUMBERS												
LANGUAGE ARTS SKILLS/ PROCESSES	CLASSIFYING												
	DEVELOPING VOCABULARY												
	MANIPULATING IDEAS												
	QUESTIONING												
	RECORDING DATA												
	USING CUES												
	ACQUIRING INFORMATION												
	COMMUNICATING INFORMATION												
	A. APPRECIATING, ENJOYING, NATURE												
	1. UNDERSTANDING, NATURAL WORLD												
SCIENCE ATTITUDES	1.1 APPRECIATING NATURAL WORLD												
	1.11 COMPLEXITY, DIVERSITY, INTRICACY, ETC.												
	1.12 RESOURCE, HUMAN NEEDS												
	1.2 RESPECTING LIFE												
	1.21 INDIVIDUAL LIFE, PRECIOUS												
	1.22 SOURCE FOR CONTINUATION												
	1.23 AGING PROCESS												
	1.3 WANTING TO KNOW, UNDERSTAND												
	1.31 CONCEPTS, TERMS, TECHNIQUES, ETC.												
	1.32 ACCURATE INFORMATION												
	1.33 EXPLANATIONS, INTERPRETATIONS, PREDICTIONS												
	2. INVESTIGATIVE METHODS, NATURAL WORLD												
	2.1 SKEPTICISM, INVESTIGATION, REASONING												
	2.11 UNCERTAINTY OF INFORMATION, VERIFICATION												
	2.12 AMBIGUITY, CONTRADICTION, TENTATIVENESS												
	2.13 ORIGINAL INSIGHT, INFERENCES, ETC.												
	2.14 CAREFUL, SYSTEMATIC INVESTIGATION												
	2.15 LOGICAL REASONING, VALIDITY OF IDEAS												
	2.2 RESPECTING OTHERS, ENVIRONMENT												
	2.21 SAFETY												
	2.22 USE OF RESOURCES												
	2.23 CONTRIBUTING FAIR SHARE OF EFFORT												
	2.24 CONTRIBUTIONS, OTHERS												
	2.25 TRUTHFUL REPORTING												
	2.26 BELIEFS AND VALUES OF OTHERS												
	B. VALUING USE OF KNOWLEDGE FOR SOCIETY												
	1. THE PRACTICAL, TECHNICAL												
	1.1 SCIENTIFIC TECHNIQUES, MATERIALS												
	1.2 RESOURCEFULNESS, INNOVATIVENESS												
	1.3 TECHNIQUE EFFICIENCY, SIMPLICITY, ETC.												
	2. SERVICE THROUGH TECHNOLOGY												
	2.1 NEEDS, PROBLEMS OF OTHERS												
	2.2 BENEFITS OF TECHNOLOGICAL CHANGE												
	2.3 POTENTIAL ADVFSE CONSEQUENCES												

LIFE SCIENCE (LEVEL 1)		Activities											
		1	2	3	4	5	6	7	8	9	10	11	12
	1. NATURAL WORLD												
	1A. PLANTS, ANIMALS, NEEDS												
	1. PLANTS, PROPERTIES, NEEDS												
	1.1 PLANT PARTS, FUNCTIONS												
	1.11 ROOTS												
	1.12 LEAVES												
	1.13 STEMS, STALKS, TRUNKS, ETC.												
	1.2 PLANT PARTS, IMMEDIATE NEEDS												
	1.3 PLANT PARTS, SEASONAL CHANGES												
	1.4 PLANT GROWTH AND DEVELOPMENT, LIFE SPAN												
	1.41 SEED, SEEDLING, ADULT												
	1.42 BULB, SEEDLING, ADULT												
	1.43 LENGTH OF LIFE SPAN												
	1.5 PLANT PART VARIATIONS												
	2. ANIMALS, PROPERTIES, NEEDS												
	2.1 ANIMAL PARTS, FUNCTIONS												
	2.11 WINGS, LEGS, FINS												
	2.12 MOUTH, TEETH, JAWS, TONGUE												
	2.13 NOSTRIL												
	2.14 EYES, NOSE, EAR, TONGUE, SKIN												
	2.15 CLAWS, SHELLS, ETC.												
	2.16 BODY COVERING												
	2.17 PARTS, SOUND												
	2.2 ANIMAL PARTS, IMMEDIATE NEEDS												
	2.3 ANIMAL PARTS, SEASONAL NEEDS												
	2.4 ANIMAL GROWTH AND DEVELOPMENT, LIFE SPAN												
	2.41 INFANCY TO ADULT STAGES												
	2.42 LENGTH OF LIFE SPAN												
	2.5 ANIMALS, CONTROL CONDITIONS, NEEDS												
	2.6 ANIMALS, MOTION, NEEDS												
	2.7 ANIMAL PART VARIATIONS												
	1B. PLANTS, ANIMALS, DEPENDENCY												
	1. ANIMALS -- PLANTS												
	2. PLANTS -- ANIMALS												
	3. ANIMALS -- ANIMALS												
	1C. OBJECTS, EVENTS, PROPERTIES												
	1. OBJECT PROPERTIES, MATERIAL, CONDITION												
	1.1 OBJECT PROPERTIES, MATERIAL												
	1.11 DIFFERENT MATERIALS/PROPERTIES												
	1.12 CHANGING SIZE, SHAPE												
	1.13 SOLID, LIQUID, GAS												
	1.14 MIXTURES												
	1.2 OBJECT PROPERTIES, LOCATION IN SPACE												
	1.3 OBJECT PROPERTIES, AMOUNT OF SPACE												
	1.4 TWO OBJECTS, SAME SPACE												
	1.5 OBJECT PROPERTIES, SURROUNDING CONDITIONS												
	2. EVENT PROPERTIES, OBJECTS, SPACE, TIME												
	2.1 EVENT, TIME, PLACE IN SPACE												
	2.2 EVENT, DURATION OF TIME												
	2.3 EVENTS, SEQUENCE, ORDER, SPACE												
	2.4 TWO EVENTS, TIME												
	2.5 REPEATING EVENTS, INTERVALS OF TIME												
	2.6 EVENTS, MOTION, SPACE												
	1D. INTERACTION, OBJECTS, EVENTS												
	1. OBJECTS -- HEAT												
	1.1 HEATING, COOLING, WARMER, COLDER												
	1.2 HEATING MATERIALS, LIQUIDS, GASES												
	1.3 COOLING MATERIAL, LIQUIDS, SOLIDS												
	1.4 HEATING, COOLING, VOLUME CHANGE												
	2. OBJECT, MOTION, PUSH-PULL												
	2.1 DIRECTION OF PUSH-PULL, CHANGE IN MOTION												
	2.2 SIZE OF PUSH-PULL, OBJECT MASSIVENESS, MOTION												
	2.3 SURFACE CONDITION, SIZE OF PUSH-PULL, MOTION												
	3. OBJECTS, SUPPORTED BY OBJECTS												
	3.1 UNIFORM BALANCE BEAM												
	3.11 TWO OBJECTS, EQUAL WEIGHT, BALANCE POINT												
	3.12 TWO OBJECTS, DIFF. WEIGHT, BALANCE POINT												
	3.2 OBJECTS, FLOATING, SINKING												

SYLLABUS - PROGRAM CORRELATION CHART
LEVEL II, GRADES 3-4

		Activities												
		1	2	3	4	5	6	7	8	9	10	11	12	13
INQUIRY SKILLS	CLASSIFYING	/												
	CREATING MODELS	/												
	FORMULATING HYPOTHESES	/												
	GENERALIZING	/												
	IDENTIFYING VARIABLES	/												
	INFERRING	/												
	INTERPRETING DATA	/												
	MAKING DECISIONS	/												
	MANIPULATING MATERIALS	/												
	MEASURING	/												
	OBSERVING	/												
	PREDICTING	/												
	RECORDING DATA	/												
	REPLICATING	/												
	USING NUMBERS	/												
LANGUAGE ARTS SKILLS/ PROCESSES	CLASSIFYING	/												
	DEVELOPING VOCABULARY	/												
	MANIPULATING IDEAS	/												
	QUESTIONING	/												
	RECORDING DATA	/												
	USING CUES	/												
	ACQUIRING INFORMATION	/												
	COMMUNICATING INFORMATION	/												
SCIENCE ATTITUDES	A. APPRECIATING, ENJOYING, NATURE	/												
	1. UNDERSTANDING, NATURAL WORLD	/												
	1.1 APPRECIATING NATURAL WORLD	/												
	1.11 COMPLEXITY, DIVERSITY, INTRICACY, ETC.	/												
	1.12 RESOURCE, HUMAN NEEDS	/												
	1.2 RESPECTING LIFE	/												
	1.21 INDIVIDUAL LIFE, PRECIOUS	/												
	1.22 SOURCE FOR CONTINUATION	/												
	1.23 AGING PROCESS	/												
	1.3 WANTING TO KNOW, UNDERSTAND	/												
	1.31 CONCEPTS, TERMS, TECHNIQUES, ETC.	/												
	1.32 ACCURATE INFORMATION	/												
	1.33 EXPLANATIONS, INTERPRETATIONS, PREDICTIONS	/												
	2. INVESTIGATIVE METHODS, NATURAL WORLD	/												
	2.1 SKEPTICISM, INVESTIGATION, REASONING	/												
	2.11 UNCERTAINTY OF INFORMATION, VERIFICATION	/												
	2.12 AMBIGUITY, CONTRADICTION, TENTATIVENESS	/												
	2.13 ORIGINAL INSIGHT, INFERENCES, ETC.	/												
	2.14 CAREFUL, SYSTEMATIC INVESTIGATION	/												
	2.15 LOGICAL REASONING, VALIDITY OF IDEAS	/												
	2.2 RESPECTING OTHERS, ENVIRONMENT	/												
	2.21 SAFETY	/												
	2.22 USE OF RESOURCES	/												
	2.23 CONTRIBUTING FAIR SHARE OF EFFORT	/												
	2.24 CONTRIBUTIONS, OTHERS	/												
	2.25 TRUTHFUL REPORTING	/												
	2.26 BELIEFS AND VALUES OF OTHERS	/												
	B. VALUING USE OF KNOWLEDGE FOR SOCIETY	/												
	1. THE PRACTICAL, TECHNICAL	/												
	1.1 SCIENTIFIC TECHNIQUES, MATERIALS	/												
	1.2 RESOURCEFULNESS, INNOVATIVENESS	/												
	1.3 TECHNIQUE EFFICIENCY, SIMPLICITY, ETC.	/												
	2. SERVICE THROUGH TECHNOLOGY	/												
	2.1 NEEDS, PROBLEMS OF OTHERS	/												
	2.2 BENEFITS OF TECHNOLOGICAL CHANGE	/												
	2.3 POTENTIAL ADVERSE CONSEQUENCES	/												

Level II continued		Activities												
		1	2	3	4	5	6	7	8	9	10	11	12	13
LIFE SCIENCE (LEVEL II)	IIA. PLANTS, ANIMALS, NEW GENERATIONS													
	1. FLOWERS, SUFFICIENT SEEDS, SURVIVAL, NEW GENERATION													
	1.1 GENERATION, STAGES, LIFE CYCLE													
	1.2 FLOWERS, SEEDS													
	1.21 POLLEN TRANSFER, SEEDS													
	1.22 POLLEN TRANSFER AIDS													
	1.23 SEEDS, FRUIT													
	1.3 SEED CHARACTERISTICS, SURVIVAL													
	1.31 DISPERSAL													
	1.32 SEVERE CONDITIONS, TEMPERATURE, DROUGHT													
	1.33 GERMINATION, SUITABLE CONDITIONS													
	1.34 STORED FOOD													
	1.4 OTHER STRUCTURES, OFFSPRING													
	1.5 PLANT POTENTIAL FOR OFFSPRING													
	1.51 NUMBERS OF FLOWERS, SEEDS													
	1.52 ACTUAL CONDITIONS, SURVIVAL POPULATION													
	2. FEMALE ANIMALS, SUFFICIENT YOUNG, SURVIVAL, NEW GEN.													
	2.1 GENERATION, STAGES, LIFE CYCLE													
	2.2 CARE FROM ADULTS, LIVE, THRIVE													
	2.3 YOUNG ANIMALS, LIVE, THRIVE, INDEPENDENT													
	2.4 ANIMAL POTENTIAL FOR OFFSPRING													
	2.41 ACTUAL CONDITIONS, SURVIVAL, POPULATION													
PHYSICAL SCIENCE (LEVEL II)	IIB. DIFFERENT KINDS, PLANTS, ANIMALS, DEPENDENCY, COMMUNITY													
	1. PLANTS, ANIMAL FOOD SUPPLY, SUN ENERGY													
	1.1 FOOD CHAIN													
	1.2 FOOD WEB													
	2. POPULATION SIZE, DEPENDENCIES, FOOD													
	2.1 ANIMAL POPULATION, FOOD SUPPLY													
	2.2 ANIMAL POPULATION CHANGE, FOOD SUPPLY CHANGES													
	IIC. ENERGY, MATERIAL, FORMS, PROPERTIES													
	1. OBJECT PROPERTIES, FORMS, AMTS., PROP. OF MATERIALS													
	1.1 MATERIAL PROPERTIES, FORM													
	1.11 SHAPE													
	1.12 SOLID, LIQUID, GAS													
	1.13 SIZE OF CONTAINED SOLID PARTICLES													
	1.2 OBJECT PROPERTIES, AMOUNT OF MATERIAL													
	2. ENERGY FORM, AMOUNT, ABILITY TO MOVE													
	2.1 ENERGY FORMS													
	2.2 ENERGY MOVEMENT, BETWEEN, THROUGH													
	2.3 ENERGY, AMOUNTS AVAILABLE													
	IID. INTERACTIONS, MATERIALS, ENERGY, SYSTEMS													
	1. ENERGY CHANGES, INTERACTIONS													
	2. ENERGY TRANSFER, SYSTEM													
	3. ENERGY, INTERACTION, OBJECT PROPERTIES													

SYLLABUS - PROGRAM CORRELATION CHART
Level III, Grades 5 - 6

		Activities												
		1	2	3	4	5	6	7	8	9	10	11	12	13
INQUIRY SKILLS	CLASSIFYING													
	CREATING MODELS													
	FORMULATING HYPOTHESES													
	GENERALIZING													
	IDENTIFYING VARIABLES													
	INFERRING													
	INTERPRETING DATA													
	MAKING DECISIONS													
	MANIPULATING MATERIALS													
	MEASURING													
	OBSERVING													
	PREDICTING													
	RECORDING DATA													
	REPLICATING													
	USING NUMBERS													
LANGUAGE ARTS SKILLS/ PROCESSES	CLASSIFYING													
	DEVELOPING VOCABULARY													
	MANIPULATING IDEAS													
	QUESTIONING													
	RECORDING DATA													
	USING CUES													
	ACQUIRING INFORMATION													
	COMMUNICATING INFORMATION													
SCIENCE ATTITUDES	A. APPRECIATING, ENJOYING, NATURE													
	1. UNDERSTANDING, NATURAL WORLD													
	1.1 APPRECIATING NATURAL WORLD													
	1.11 COMPLEXITY, DIVERSITY, INTRICACY, ETC.													
	1.12 RESOURCE, HUMAN NEEDS													
	1.2 RESPECTING LIFE													
	1.21 INDIVIDUAL LIFE, PRECIOUS													
	1.22 SOURCE FOR CONTINUATION													
	1.23 AGING PROCESS													
	1.3 WANTING TO KNOW, UNDERSTAND													
	1.31 CONCEPTS, TERMS, TECHNIQUES, ETC.													
	1.32 ACCURATE INFORMATION													
	1.33 EXPLANATIONS, INTERPRETATIONS, PREDICTIONS													
	2. INVESTIGATIVE METHODS, NATURAL WORLD													
	2.1 SKEPTICISM, INVESTIGATION, REASONING													
	2.11 UNCERTAINTY OF INFORMATION, VERIFICATION													
	2.12 AMBIGUITY, CONTRADICTION, TENTATIVENESS													
	2.13 ORIGINAL INSIGHT, INFERENCES, ETC.													
	2.14 CAREFUL, SYSTEMATIC INVESTIGATION													
	2.15 LOGICAL REASONING, VALIDITY OF IDEAS													
	2.2 RESPECTING OTHERS, ENVIRONMENT													
	2.21 SAFETY													
	2.22 USE OF RESOURCES													
	2.23 CONTRIBUTING FAIR SHARE OF EFFORT													
	2.24 CONTRIBUTIONS, OTHERS													
	2.25 TRUTHFUL REPORTING													
	2.26 BELIEFS AND VALUES OF OTHERS													
	B. VALUING USE OF KNOWLEDGE FOR SOCIETY													
	1. THE PRACTICAL, TECHNICAL													
	1.1 SCIENTIFIC TECHNIQUES, MATERIALS													
	1.2 RESOURCEFULNESS, INNOVATIVENESS													
	1.3 TECHNIQUE EFFICIENCY, SIMPLICITY, ETC.													
	2. SERVICE THROUGH TECHNOLOGY													
	2.1 NEEDS, PROBLEMS OF OTHERS													
	2.2 BENEFITS OF TECHNOLOGICAL CHANGE													
	2.3 POTENTIAL ADVERSE CONSEQUENCES													

		Activities												
		1 2 3 4 5 6 7 8 9 10 11 12 13												
Level III, continued														
LIFE SCIENCE (LEVEL III)	IIIA. LIVING THINGS, AFFECT ON ENVIRONMENT													
	1. LIFE OF PLANT, ENVIRONMENTAL CONDITIONS													
	1.1 PLANT HEALTH, GROWTH, DEVELOPMENT													
	1.2 PLANT CHANGE, ENVIRONMENTAL CHANGE, SURVIVAL													
	1.21 PLANT PART MOVEMENT													
	1.22 PLANT PART FORMATION													
	1.3 GREEN PLANT, LIGHT FORMATION													
	1.31 LEAVES, LIGHT ABSORPTION, ENERGY TRANSFORM.													
	1.32 ABSORBED AND STORED ENERGY, UTILIZATION													
	1.33 STORED ENERGY, FOOD SUPPLY, SEED, GROWING PLANT													
	1.4 PLANT, AFFECT, ENVIRONMENT													
	2. LIFE OF ANIMAL, ENVIRONMENTAL CONDITIONS													
	2.1 ANIMAL HEALTH, GROWTH, DEVELOPMENT													
	2.2 ANIMAL BEHAVIOR CHANGE, ENVIRONMENTAL CHANGE													
	2.21 ANIMALS MOVEMENT, OPTIMAL CONDITIONS													
	2.22 ANIMAL CHARACTERISTICS, ENVIRON. INFLUENCE													
	2.23 ROUTINE BEHAVIOR, ENVIRONMENTAL INFLUENCE													
	2.3 SOURCES OF ENERGY													
	2.31 STORED ENERGY, FOOD													
	2.32 HEAT ENERGY, SUN													
	2.33 HEAT ENERGY, FUEL UTILIZATION													
	2.4 ANIMAL BEHAVIOR, AFFECT, ENVIRONMENT													
	IIIB. ENVIRON. CONDITIONS, INFLUENCE, POPULATIONS, COMMUNITY													
	1. DIFFERENT KINDS, POPULATIONS, VARIOUS ENVIRONMENTS													
	2. ENVIRONMENTAL CONDITION CHANGE, POPULATION SIZE CHANGE													
	2.1 CONDITIONS, DIRECT EFFECT, POPULATION SIZES													
	2.2 CONDITIONS, DIRECT EFFECT, FOOD CHAIN													
PHYSICAL SCIENCE (LEVEL III)	IIIC. ENERGY, WITHIN MATERIAL, POSITION, MOTION, OBJECTS													
	1. ENERGY TRANSFER WITHIN MATERIALS													
	1.1 ELECTRICAL ENERGY, CIRCUITS													
	1.11 POSITIVE, NEGATIVE CHARGES													
	1.12 BATTERIES, ENERGY STORAGE													
	1.13 COMPLETE CIRCUIT, ENERGY FLOW													
	1.14 RATE OF FLOW, VOLTAGE, TRANSFER AMOUNT													
	1.15 MAGNETIC FIELD, FLOWING ELECTRICITY													
	1.16 MOVING MAGNET, FLOW OF ELECTRICITY													
	1.2 INTERACTIONS, MATERIALS, ENERGY													
	1.21 NEW MATERIALS													
	1.22 STARTING ENERGY													
	1.23 ENERGY EMITTED													
	1.24 ENERGY ABSORBED													
	1.3 HEAT FLOW													
	1.31 AMOUNT OF MATERIAL													
	1.32 TYPES OF MATERIAL													
	1.33 TEMPERATURE DIFFERENCE													
	1.34 MOVEMENT OF MATERIAL													
	2. ENERGY TRANSFER, MOTION, OBJECTS													
	2.1 WORK, ENERGY TRANSFER													
	2.11 LIFTING OBJECTS, HEAVY													
	2.12 MOVING OBJECTS, SPEED													
	2.2 AMOUNT OF WORK, FORCE, DISTANCE													
	2.21 INCLINED PLANE, LEVER, CHANGING FORCE													
	2.22 SIMPLE MACHINES, CHANGING DISTANCE													
	2.23 MACHINE, OBJECT-FORCE-DISTANCE RELATIONSHIP													
	2.3 MAN-MADE TOOLS, MACHINES													
	2.4 FORCES, LIQUIDS, GASES													
	2.41 CLOSED CONTAINER, FORCE													
	2.42 FORCE, AREA, PRESSURE													
	2.43 PRESSURE, DEPTH, FLUID													
	IIID. MATERIAL AND ENERGY TRANSFER, INTERACTIONS, SYSTEMS													
	1. CHANGES IN FORM													
	2. CHANGES IN LOCATION													
	3. LOSSES FROM A SYSTEM													
	4. MAINTAINING INTERACTIONS													

Level III, continued		Activities												
		1	2	3	4	5	6	7	8	9	10	11	12	13
ECOSYSTEMS	IIIE. ECOSYSTEM													
	1. MATERIAL RECYCLING, PHYS. ENVIRON., LIVING COMMUNITY													
	1.1 MATERIAL, ABSORPTION, GREEN PLANTS													
	1.2 MATERIAL ABSORPTION, ANIMALS													
	1.3 MATERIAL UTILIZATION, WASTE													
	1.4 MATERIAL DECAY													
	2. ENERGY EXCHANGES, PHYS. ENVIRON., LIVING COMMUNITY													
	2.1 ENERGY INPUT, PHYSICAL ENVIRONMENT													
	2.11 ENERGY ABSORPTION, AIR, WATER, LAND													
	2.12 ENERGY EXCHANGES, CLOUDS, RAIN													
	2.13 ENERGY EXCHANGES, WINDS, WAVES													
	2.2 ENERGY INPUT, LIVING COMMUNITY													
	2.21 SOLAR ENERGY, ABSORP., GREEN PLANT UTIL.													
	2.22 STORED ENERGY, PLANTS, ANIMAL UTILIZATION													
	2.23 ENERGY EXCH., DEAD PLANTS-ANIMAL, DECAY													
	3. INTERACTIONS, CAUSE AND EFFECT, ECOSYSTEM PARTS													

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